The Dock & Harbour Authority

Vol. XLII NOVEMBER, 1961 Monthly 2s. 6d.

Dredging round the world **8** ROCHESTER

8,000 tons in first week

The "Garsem", property of M.B. Dredging Co. Ltd., is the fourth Priestman Grab Dredger which these enterprising Dredging Contractors have purchased in the last 8 years.

This dredger is fitted with a diesel-driven Priestman No. 750 Grab Dredging Crane which operates a $3\frac{1}{2}$ cubic yard mud grab at a maximum radius of 32′ 0″ to a depth of 70′ 0″ below water level. The vessel is of the non-propelled type and has dimensions of 106′ 0″ length, 30′ 0″ beam with a depth of 7′ 0″ and a loaded draft of under 4′ 0″.

Power for the two electric winches; for lighting, heating, cooking, pumping and battery charging is provided by an 80 KW alternator. Nearly one mile of electric cable was used in all the circuits on the vessel.

Accommodation is provided below decks for 4 men, and consists of a sleeping cabin, galley with electric stove and water boiler, and a separate washplace.

Long mooring wires are provided on the 6 drums of the two winches, and with the crane wires, a total of over 5,000 feet of wire rope is fitted to this craft.

The No. 750 size Dredging Crane has pneumatic controls, and the driver sits in an armchair with good all-round vision of the working end of the crane. A 300 tons capacity barge can be filled with mud in 45 minutes when working at a depth of 37′ 0″, and in its first week the "Garsem" handled 8,000 tons of spoil.

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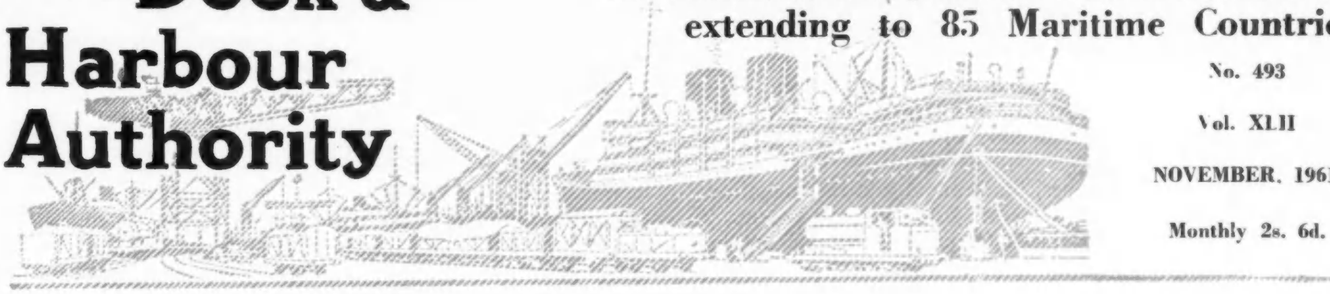


Editorial Notes

Oil Terminal at Kalundborg, Denmark

The wider dispersal of refinery capacity throughout the world entails a pattern of oil distribution which is constantly changing. Oil refineries constitute a form of investment from overseas which, for various reasons, host countries are anxious to attract and which has, moreover, a sound economic basis by reason of the savings accruing from the transport of homogeneous cargoes in large units.

The difficulty of finding sites for oil refineries accessible to very large vessels importing the feedstock and at the same time suitable for the economical distribution of the refined product is a very real one. In most cases it follows that the further distribution of product oil must also be sea borne. This does not mean, necessarily, that **all** refinery intakes must contemplate the handling of the largest super tankers at their maximum summer draught of 47-ft. or over. Often arrangements may be made for lightening the vessel at one point of call and finally discharging her at another, though this is rather dependent on the internal workings of the oil industry and in the particular characteristics of the crude oil which a refinery is designed to process. Furthermore, for many years to come, and perhaps permanently, there will be ample tonnage available of less extreme size perhaps better adapted for supplying the needs of the smaller refineries. In any event a problem frequently to be encountered will be that of providing facilities for handling a relatively small number of large vessels importing the feedstock, possibly not fully laden, and for a much larger number of general purpose vessels distributing the refined product. Both types make different demands on equipment, tug power and personnel concerned in their movements and unless layout and handling techniques are carefully contrived, much of the resources to be provided will often be under-employed.

The pattern of the facilities provided at Kalundborg which are described in an article in this issue clearly recognises the dilemma and the manner in which it has been resolved will be studied with keen interest. The site of the oil refinery and intake is on the western side of the island of Sjaelland, 50 miles or so due west of Copenhagen on the opposite seaboard of that island. It appears that another refinery is to be constructed at Fredericia on the mainland of Jutland some four hours steaming westwards from Kalundborg. The situation in Kalundborg fiord starts off with the outstanding natural advantages of reasonably sheltered and virtually tideless water. The difficulties of maintaining adequate depth of water, accurately positioning vessels for berthing and providing sufficient fendering of quay structures are therefore much reduced, although the presence of some tide can often be turned to advantage when taking a vessel off a wharf. There remains of course the effect of windage to which tankers are particularly susceptible.

It will at once be noticed that the turning area allotted for large tanker movements is surprisingly small and that the disposition of mooring points is much more compact than is usual with installations of this kind. This is achieved by means of an arrangement of "Bean" bollards and "Seebeck" towing hooks allowing for more uplift, in place of the customary mushroom bollards, so that the scope of mooring rope layout is greatly reduced. At the same time, the manhandling of heavy bights of cordage is facilitated and quick release in emergency easily performed. The procedure on unberthing is to angle the ship around a turning dolphin with only one tug on a headrope, maintaining a close control of the stern position throughout. The outsize towing hooks provided will be recognised as a borrowing from tug practice; our readers will no doubt recall the name "Seebeck" in connection with the Seebeck Ring, a simple and effective device for counteracting the heeling moment on a tug caught by a beam-on pull.

For the rest, the installation provides for the discharge of feedstock oil through a 30-in. diameter pipeline with angle flow-boom capacity for hose connection so that high discharge rates of which modern tankers are capable can be achieved. On the loading side, in addition to the usual service lines, eight product lines are available with their associated hose handling equipment by which any downgrading by contamination is avoided. All the equipment is operated by electric motors and where these are in the danger area presumably they are flame-proofed.

The layout and detail design of the whole installation illustrates the very great improvement which has taken place in these contrivances which, by this example, appear now to have just about reached the peak of their development. It is perhaps in the arrangements for loading crude oil at the production centres where the next round of advances in oil-handling technique can be expected. Indeed, the remarkable bow mooring device just installed by Esso Standard Libya at Marsa el Brega on the Gulf of Sirte may already point the way to future developments in this direction.

Anglo-French Channel Crossing Discussions

As stated in these columns last month, we are publishing in this issue an article reviewing a number of schemes put forward to provide a link between the United Kingdom and the Continent. The author gives a clear and unbiased exposition of the arguments put forward by the protagonists in favour of either a tunnel or a bridge and has drawn attention to the problems involved.

It was recently reported in the daily press that, at a meeting in Paris early this month, leaders of the two rival projects expressed hopes for an early decision on whether it should be a tunnel or a bridge. The officials, M. Louis Armand a promoter of the

Franco-British Channel tunnel study group, and M. Georges Gallienne, head of the French Road Users' Association and deputy chairman of the Channel bridge study group, debated their respective schemes at a meeting organised by the French Parliamentary committee for trade. Both insisted on the need for an early decision as otherwise large new investments would have to be made in six months' time for new ferries and port facilities which are urgently needed to cope with the increasing traffic across the Channel.

Comparing the two schemes, M. Armand said the tunnel project would have the better chance of being adopted because its cost of 1,500 million new francs (about £109 million sterling) would be only half that needed for a bridge. M. Gallienne said that the higher investments needed for a bridge would not upset the British or French capital market because a considerable portion of the funds would be raised in other Common Market countries and in the United States.

It has since been announced that Mr. Ernest Marples, Minister of Transport, will meet M. Robert Buron, French Minister of Transport and Public Works, in Paris this week for preliminary discussions about the proposals for either a tunnel or bridge. They will be accompanied by officials from both sides.

The Development of the Clyde Area

The start of the construction of a large dry dock at Greenock, on the River Clyde was officially inaugurated last month by Mr. J. S. Maclay, the Secretary of State for Scotland. Initially, the dock will be 1,000-ft. long and 145-ft. wide at the entrance but provision will be made for the length to be extended to 1,150-ft. if required. A repair and fitting-out jetty and a tanker cleaning installation is also included in the scheme which is expected to cost £4,250,000. When completed, the dock should be a valuable asset to the Clyde area. It will be the largest in the United Kingdom and one of the largest in the world and should attract business not only from this country but also from the Continent and elsewhere.

Calling attention to the close co-operation between the shipbuilding and other commercial and shipping interests who, with Government assistance, played such an important part in financing the enterprise, Mr. Maclay said the new project was of vital importance to the economy of Scotland as a whole and he would like to see that co-operation grow even closer.

Mr. Maclay also referred to the unification of the Clyde Authorities, a scheme which has been mooted from time to time over the years. He said that, as long ago as 1945, the Clyde Estuary Committee under Lord Cooper was not only sympathetic to the additional dry dock facilities which had now been inaugurated, but also recommended a new authority to combine the present separate undertakings responsible for port and navigational facilities in the upper estuary and river. They believed that such a new administration was necessary in the best interests of the operation, expansion and development of the area of the Clyde and hinterland. The Committee under the chairmanship of Lord Rochdale appointed by the Minister of Transport to inquire into major docks and harbours of Great Britain were including Glasgow in their examination and the possible unification of the Clyde Authorities would, no doubt, be one of the matters to which they would given attention.

Improved Shipping Control at Melbourne

A move to introduce a system of co-ordinated control of shipping movements in the Port of Melbourne has been initiated by the Harbour Trust Commissioners and preliminary conferences and discussions to work out details have been held between officers of the Trust and representatives from shipping interests, tug owners, pilots, oil companies and other port users.

Proposals under consideration include the establishment of a control centre which would be manned 24 hours a day by master mariners and through which all requirements and information could be channelled. In addition to other forms of communication the centre would have direct visual contact with the entire port area.

Under the existing system the Trust's Traffic Manager notifies the ships' agents as to the berths which have been allocated, and the agents in turn place orders for tugs, pilots, and arrange for mooring parties at the required times, with Trust officers in charge of the particular areas. The pilot service is a separate organisation from the Port Authority, while the tugs are owned and operated by private companies. In addition, the agents also have to arrange for boatmen, Customs, Port Health and Immigration inspections, etc.

The actual arrangement for ships' movements are made each day by a representative of the tug operators who pool their information and resources for this purpose. For guidance in formulating a programme, the Trust has laid down a set of movement priorities headed by passenger and migrant ships and followed by inward cargo ships, and ships changing berth with labour waiting; tankers inward or changing berth; outward tankers; outward cargo ships in order of tugs requisitioned; inward cargo ships in order of arrival.

The regulating of traffic up and down the river is controlled by the Trust's signal stations at Dockhead in the upper reaches of the port, and Breakwater at the port entrance.

Port administration and shipping control varies from port to port throughout the world and, at Melbourne, the present system grew up with the port, and, despite its weaknesses, has worked successfully over the years. Today, however, it is necessary to increase efficiency in every sphere of port working.

International Standards Committee on Cranes

Conflicting national standards for materials and equipment can be just as big a barrier to international trade as tariff walls. Nowhere is this more true than in the field of crane manufacture. Most countries (including the U.K.) have standards for cranes, and at present difficulties arise with the export of cranes from one country to another due, in particular, to the varying methods adopted for rating cranes in respect of their safe working loads.

The first step towards unification of these conflicting standards has now been taken; the International Organization for Standardization has set up a new technical committee on cranes and excavators. This committee, which has just concluded its first series of meetings (held at British Standards House, London) is concerned particularly with terminology, load rating, materials, design, stability, testing and safety.

Delegates from Finland, France, Germany, the Netherlands, Poland, Portugal and the U.K. attended the meetings which were primarily concerned, at this stage, with reaching agreement on definitions of fundamental technical terms. In addition, they considered proposals made for a standard range of capacities for cranes, a point which will be further discussed at a future meeting.

Other matters to which the committee will give priority are: Stability requirements (including consideration of wind loads); testing procedures; crane ropes and associated pulleys, drums and so on; crane structures.

A working group was set up to draft proposals initially in respect of the first four subjects and when they have dealt with these, the Committee are to consider the establishment of working groups to deal with builders' tower cranes, jib cranes, overhead travelling and bridge cranes, mobile cranes and single bucket excavators.

Marine Terminal for Oil Refinery at Kalundborg, Denmark

Details of Design and Construction

by P. GARDE-HANSEN, B.Sc.

Introduction

The Tidewater Oil Co. under the leadership of Mr. Jean Paul Getty was the first of the large oil companies that decided to build an oil refinery in Denmark. The Company "Dansk Veedol A/S" was therefore formed in the summer of 1959 for this purpose and for the marketing of Tidewater products in Denmark.

The Tidewater Company has been followed since by the Gulf Oil and the Shell Companies, and refineries are now also under construction near Skelskoer and planned near Fredericia.

Denmark's present yearly consumption of oil products is approximately 5 million tons. The Kalundborg refinery will have an initial capacity of one million tons, and the two other refineries mentioned of 1½ million and it is believed 2½ million tons respectively, the latter figure not having been made public yet.

The Kalundborg refinery is being built under the direction of Mr. R. M. Hunt of the Tidewater Company. The main contractor for the refinery proper is Foster-Wheeler Ltd. The designers of and contractors for the marine terminal, being the subject of this article, were Christiani and Nielsen A/S. The contract included not only the civil engineering work but also all installations and pipework.

Selection of Site

The selection of the site for the refinery was governed principally by the desire of obtaining a site for the marine terminal fulfilling as far as possible, the conditions of being sheltered, of requiring a minimum of dredging in order to obtain access from existing deep water channels, and of being relatively free from ice during the winter.

Kalundborg fiord meets to a large extent these requirements, see Fig. 1. Furthermore Kalundborg is located very centrally for distribution by sea to the whole of Scandinavia.

Subsoil Conditions

The Kalundborg fiord and the surrounding country are moraine formations. The subsoil conditions are, therefore, very irregular with clay, gravel and sand being mixed in various proportions, and with large boulders intermingled. A boulder weighing at least 25 tons was encountered in the excavation for one of the caissons, and similar boulders were also encountered during the dredging.

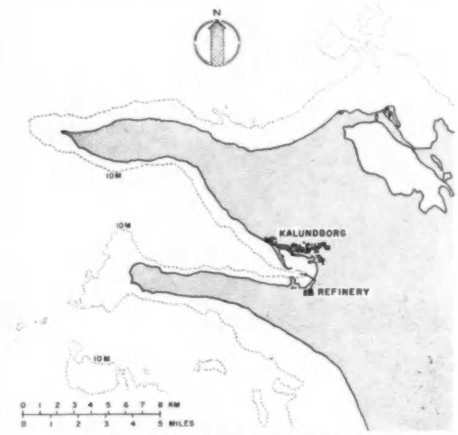


Fig. 1. Map of Kalundborg Fiord.

The irregularity of the subsoil made a very great number of borings and relevant laboratory tests necessary before the design could be completed, and even then unexpected conditions were possible.

The presence of boulders made the pile-driving very arduous, and the precast elements for the superstructure had to be designed with tolerance for some inaccuracy in the position of the piles.

Layout

The layout of the terminal is shown on Fig. 2. The access channel and the turning basin have been dredged to a depth sufficient for tankers of approximately 50,000 tons deadweight, but the pier has been designed so that, after further dredging, it can

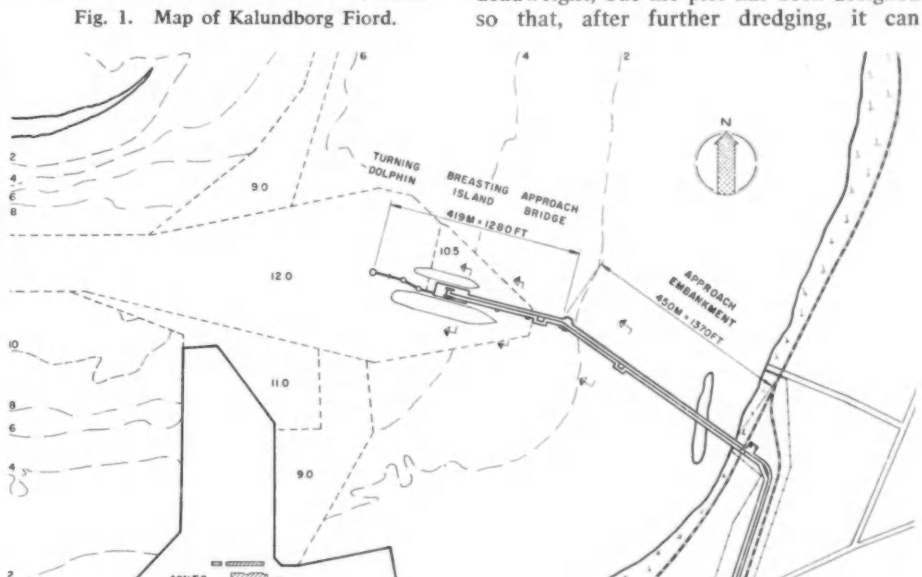
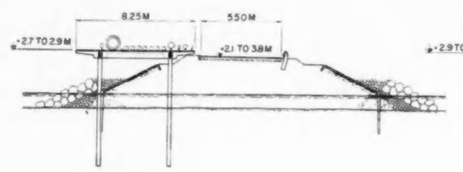
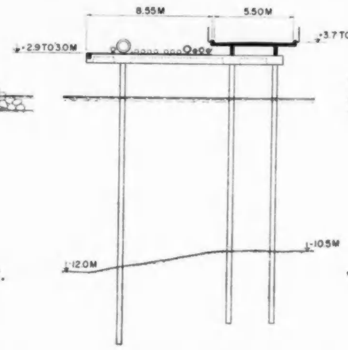
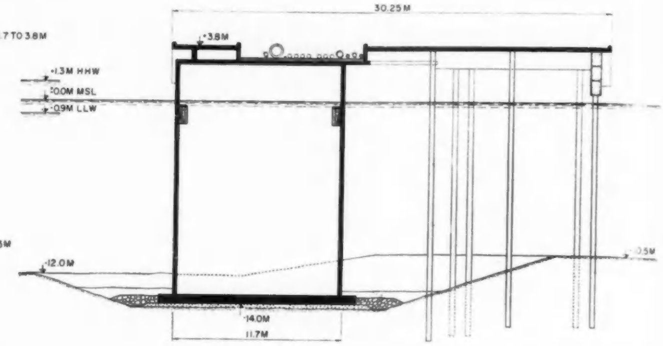


Fig. 2 General Lay-out.







CROSS SECTIONS

Fig. 3 (above). Approach Embankment.
Fig. 4 (centre) Approach Bridge.
Fig. 5 (right). Breasting Island.

accommodate tankers of up to 73,000 tons deadweight and 782-ft. length.

The basin has been dredged to 39-ft. 6-in. and 34-ft. 6-in. below low water, on the south and north sides of the pier respectively, but this has been designed for an increase in the dredged depth to 42-ft. 9-in. below low water on the south side.

There is practically no tidal variation, and it is overshadowed by the influence of the wind. The maximum height of waves occurs with a WNW wind, but reaches 3-ft. 4-in. only (Mean wave height).

The angle between the centrelines of the approach embankment and the approach bridge has the explanation, that the positions of the root of the approach embankment and of the turning dolphin were predetermined, and that it was desired to place the berths at the most favourable angle with prevailing winds and maximum waves.

The root of the approach embankment was determined by its position in relation to the refinery. A still more westernly position would have been even more favourable, but the property was not obtainable.

The position of the turning dolphin was determined partly by certain distances having to be kept from the channel to the Kalundborg harbour and from the pier at the Asnæs power station, and partly by subsoil conditions.

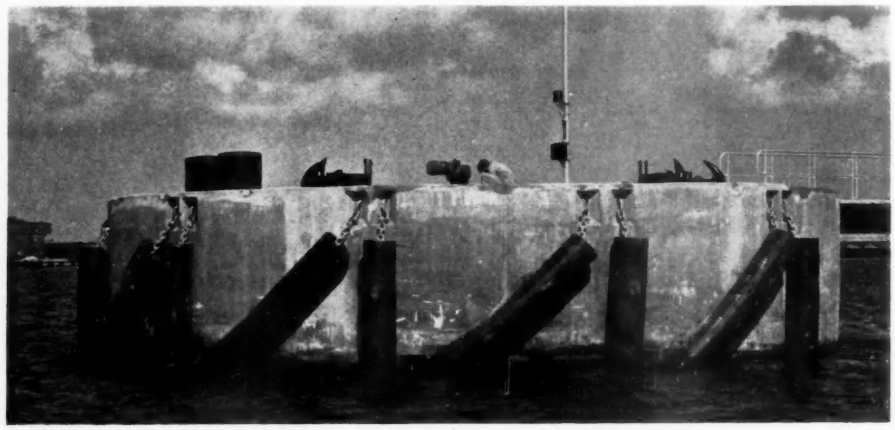


Fig. 6. Fender work on turning dolphin.

Design Data

The reinforced concrete work is designed in accordance with the Danish codes of practice.

(1) Traffic load: On approach bridge and breasting island a uniformly distributed load of 100 lbs. per sq. ft. and a 12 tons truck with 40% impact. On catwalk to turning dolphin and on dolphins a uniformly distributed load of 50 lbs. per sq. ft.

(2) Load from pipes: The actual weight of the filled pipes or a uniformly distributed load of 60 lbs. per sq. ft., whichever gives the highest stresses. Horizontal friction forces on pipe supports are taken as 25% of the vertical loads.

(3) Wind loads: On ordinary structures according to Danish regulations.
On a 16,000 t DWT tanker, empty: 150 t.
On a 54,000 t DWT tanker, empty: 350 t.
On a 73,000 t DWT tanker, empty: 500 t.
On hose handling structure: 100 t.

(4) Snow loads: On roofs and on pipes 15 lbs. per sq. ft., on other places 20 lbs. per sq. ft.

(5) Pulls on bollards: These are taken as the nominal pulls i.e. 50 or 100 t.

(6) Impact from berthing ships: The energy E to be absorbed by the fender and the load P to be taken by the structure are the following:
Turning dolphin:
$E = 800$ inch x t, $P = 500$ t
Southern berth:
$E = 1200$ inch x t, $P = 260$ t
Northern berth:
$E = 800$ inch x t, $P = 260$ t

Structural Details

The approach embankment is an earthen embankment, the fill for which has come from the grading for the refinery installations. The nature of the fill is clayey sand under mean water and moraine clay above this. The slopes of the embankment have been given the traditional Danish protection as shown in Fig. 3.

The approach bridge is a reinforced concrete bridge, the substructure for which is composed of vertical reinforced concrete piles, placed in bents at 23-ft. centres, and of 2 cylindrical reinforced concrete caissons. Side stiffness is provided by the latter, and they also serve as supports for bollards.

The superstructure of the approach bridge consists of precast elements, the heaviest of which weighs 25 tons. These elements were fabricated in a yard located on the east side of the Asnæs pier and taken out one by one hanging in a 35-ton floating crane.

A precast structure was chosen in order to increase speed of construction.

A normal section in the approach bridge is shown on Fig. 4.

The breasting island is also a reinforced concrete structure supported partly by vertical piles and partly by cylindrical caissons. The superstructure is, however, to a very great extent cast in situ in order to give the greatest possible rigidity.

A section in the breasting island is shown on Fig. 5. There cannot be said to be a "normal" section in the breasting island, as it has to accommodate foundations for the hose handling structure and for other in-

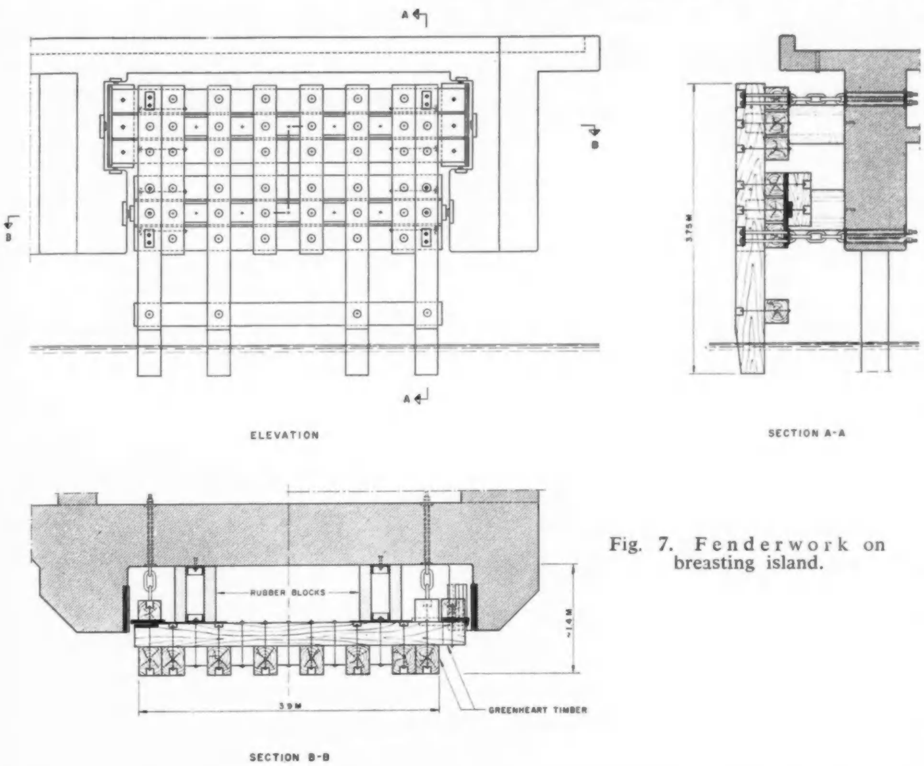


Fig. 7. Fenderwork on breasting island.

stallations, troughs for waste oil etc., etc.

The breasting island is connected with the turning dolphin by a reinforced concrete gangway supported by two intermediate caissons and by vertical piles. One of the intermediate caissons serves as support for bollards. The gangway proper consists of 4 precast prestressed elements each weighing 27 tons and having spans of 90-ft.

Caissons

The caissons are all cylindrical, but of varying diameter according to their height and the loads on them. The foundation depths for the caissons vary from 7-ft. to 17-ft. below the dredged level of the berths. Except for one, all the caissons are founded on a layer of sand. The exception is the caisson next to the turning dolphin which is founded on moraine clay.

Fig. 5, the cross-section in the breasting island, gives some details of the caissons and their foundations. The wall thickness is 8-in. to 12-in. and the bottom thickness 1-ft. 6-in. to 2-ft. 6-in.

The caissons were cast inside a cofferdam on the east side of the Asnæs pier at the root of this, up to about one-third of their height. Two caissons were accommodated in the cofferdam simultaneously, and the cofferdam was provided with a gate, so that the cofferdam could be filled with water, and the caissons floated and taken out. They were thereafter cast to full height just outside the cofferdam, except in the case of the caisson for the turning dolphin, the draft of which would be too big for floating out to its position if completed alongside the cofferdam. The top of the walls of this caisson was therefore cast after it had been floated out to its final position.

The walls were cast in sliding forms operated by hydraulic jacks.

Construction Equipment

The construction equipment used was all of traditional types. However, it deserves mentioning that a 2-ton diesel hammer was used for the driving of the reinforced concrete piles for the approach bridge and the breasting island. The largest of these piles were 14-in. x 14-in. x 75-ft. long and weighed 7 tons.

Fenderwork

The fenderwork on the turning dolphin is shown on Fig. 6. It consists of tubular rubber fenders suspended in chains. The dimensions of the fenders are 21-in. outside diameter with 10½-in. bore, the vertical tubes being 7-ft. long and the inclined tubes being 11-ft. long. The suspension chains are 1⅜-in. galvanised steel chains.

On Fig. 7 is shown elevation, plan and section of one of the fenderworks on the south side of the breasting island. The energy absorbing element consists of four 30-in. long, 21-in. diameter rubber cylinders with a 9-in. diameter axial bore. They are fitted in such a way that they will be axially compressed when a ship is berthing. The impact is transmitted to the rubber cylinders through a timber construction, made of Demerara Greenheart (Ocotea Rodiaei). The vertical front timbers are 12-in. x 15-in. and the horizontal timbers are 12-in. x 12-in. The bolts are generally 1¼-in. diameter mild steel bolts, but some 1½-in. diameter bolts are also used.

The fender work is supported and guided by means of 2-in. thick steel plates bolted to the ends of the horizontal timbers and sliding on steel bearings cast into the heavy reinforced concrete sidewalls, which are dimensioned to take up the frictional forces on the fenderwork. It is kept in position by four 1⅜-in. galvanised steel chains. All bolts, steel plates and chains are hot dip galvanised.

The fender units on the north side are identical to those on the south side except that the length of the 21-in. diameter rubber cylinders is 20-in. only and the bore diameter is 10½-in.

All the rubber cylinders were supplied by "The Goodyear Tire & Rubber Company," and they were manufactured in their factory in Akron, U.S.A.

Bollards and Capstans

The arrangement of the bollards and the principles for mooring the ships are shown on Fig. 8. The eight "Seebeck" twin hooks are of the quick release type. One twin unit is visible on Fig. 9. They are supplied by the "Weser Werk Seebeck" in Bremerhaven, Western Germany. The other bollards as well as the 5 h.p. "Sadi" capstans are supplied by E. J. Bean Ltd., London.

The fairlead on the turning dolphin is made of two 30-in. diameter steel pipes filled with concrete and connected by a 12-in. diameter steel tube.

The fairlead is to be used, when tankers leaving the pier swing around the turning dolphin as shown on Fig. 8. During this operation the hawser fixed to the turning dolphin runs through a sector of 320°, but as a Seebeck hook can only cover a 200° sector, the hawser is carried through the eye of the fairlead before fixing it to the hook.

Hose-handling Equipment

Hose-handling structures and equipment are provided on both sides of the breasting island. These structures were designed and the equipment was supplied by Woodfield Rochester Ltd., of Rochester, England.

The equipment on the south side has 11 booms for handling three 12-in. diameter and eight 10-in. diameter hoses.

The equipment on the north side has 10 booms for handling one 12-in. diameter,

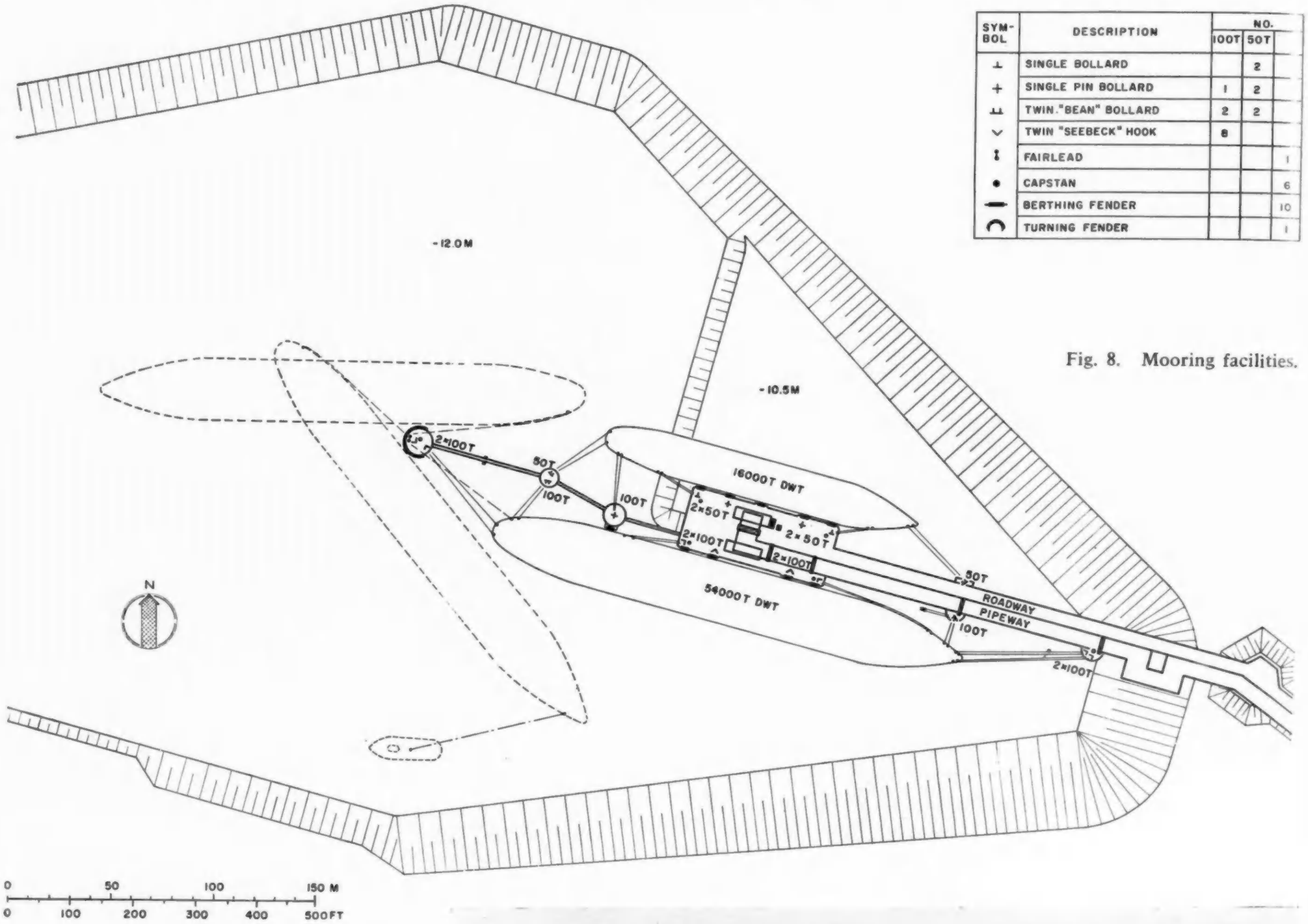


Fig. 8. Mooring facilities.

eight 10-in. diameter and one 8-in. diameter hoses.

The height of the structures are 66-ft. and 41-ft. respectively.

The winches for operating the booms are placed 33-ft. and 16-ft. above deck level respectively.

The control rooms for the operation of the booms are placed on the top of the structures.

Pipelines

The pipelines from the pier to the refinery comprise 14 pipes:

	Dia.		Dia.
Crude oil	30″	Regular petrol	10″
No. 6 fuel oil	14″	Premium petrol	10″
Gas oil	10″	Ballast water	10″
Diesel oil	10″	Fire water	10″
No. 1 fuel oil	10″	Potable water	6″
No. 2 fuel oil	10″	Steam	6″
Jet fuel	10″	Air	4″

The pipes for No. 6 fuel oil, potable water, ballast water and fire water are insulated and steamtraced, and the pipe for steam is insulated. The insulation is in all cases 2-in. Rockwool covered by heavy bituminous felt. Provision for expansion is made by two loops and corresponding anchors.

Fig. 9. "Seebeck" quick release hook.

The pipes are provided by motor controlled valves at the inter-section with the railway at the root of the pier. These valves can open or close in 60 seconds.

The crude oil pipe is provided with an automatic crude oil sampler making it possible to extract tests during the discharge of crude oil.

Electrical Installations

Electrical power is supplied from the refinery's own 50/10 KV power station by a 10 KV cable to a transformer station located at the root of the pier. The electricity is distributed from here to the hose-handling equipment, capstans, motor controlled valves, lighting, etc.

The hose-handling equipment carry in all 21 winches with 7 to 10 h.p. motors. The delivery pumps at the refinery can be electrically controlled from the pier head in the case of an emergency.

The temperatures of the oil in the pipelines are recorded electrically.

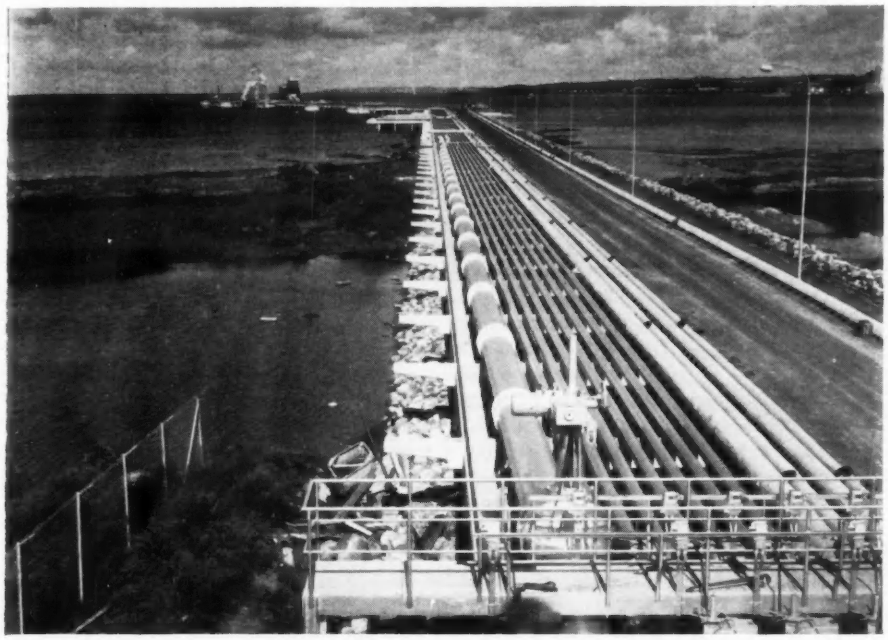


Fig. 10. General view of pier showing pipe lines with motor operated valves at foot of picture.

Safety Precautions

The 10-in. diameter firewater pipe is provided with four 2½-in. diameter hydrants at 6 different locations. The hose-handling structures are provided with sprinkler systems to prevent collapse in the case of fire. A foam tank and a mobile foam gun are kept in a heated room on the breasting island. Fire extinguishers are kept at many points for immediate action in the case of minor fires.

The whole of the breasting island is provided with an 8-in. high curb to prevent any oil accidentally spilled from running into the sea, and troughs are provided at points of greatest danger for spillage. Any oil spilled is drained to a 2,500 gallon tank suspended under the deck, and from here automatically pumped through the ballast pipe to the ballast tank in the refinery proper.

A motor boat is stationed at the pier head for use in the placing of booms for the prevention of the spreading of any oil spilled into the sea. This boat has a 350 gallon tank and a pump for the collection of the oil trapped by the booms.

Conclusion

The works on the filling for the approach embankment and on the construction yard and the temporary installations, were started in July 1960, and in August 1960 the fabrication of caissons, reinforced concrete piles and precast reinforced concrete elements was commenced.

Not much actual construction work could be done, however, until the dredging of the turning basin had been completed by the beginning of October 1960.

The civil engineering work was in the main completed in July 1961, and the installations in August 1961. The work was delayed in the spring of 1961, by a strike of five weeks' duration.

The first tanker, the 46,000-ton "Virginia Getty" was berthed on 18th August, 1961.

U.K. Port Labour Problems

Proposals for Further Decasualisation

At a meeting held in June, the National Joint Council for the Port Transport Industry affirmed its belief that a further advance towards effective decasualisation is the basic solution to the problems of the Docks Industry and appointed a Working Party to examine methods to achieve this in the light of the practical difficulties of fluctuating employment and the variation in the situation in different ports.

Under the joint chairmanship of Mr. A. J. M. M. Crighton for the employers and Mr. Frank Cousins for the unions, the Working Party has examined the position and, as a result, the National Joint Council last month issued a memorandum which it requires Local Joint Committees to study and report on by 1st January, 1962. It is emphasised, however, that the memorandum is designed simply as a basis for discussion in the ports, without commitment on either side, to fulfil the essential purposes both of directing attention in the ports to the objective of further decasualisation and of informing the Council as to opinion in the ports and the extent and range of practical problems.

The Memorandum

Throughout the sixty years of this century, and before that, the background to industrial relations in the docks, and the source of most of the industry's special problems, has been the casual system of employment. Much has been done to offset the effects of the casual system, culminating in the present Dock Labour Scheme with its control of the registers, and its attendance money and guarantee benefits in case of underemployment.

As a result, the dockworker on the main register in his port has a basic security in his registration that compares favourably with the security offered by any other industry, and despite fluctuations average earnings in the docks, taking the post-war period as a whole, have been regularly among the highest in industry. The recently instituted pension and training schemes have helped to attest to the status of dock work.

Memorandum Issued by National Joint Council

Yet the character of employment and relationships in the docks remain casual for the majority of the men. The Dock Labour Scheme benefits and high average earnings do not prevent wide fluctuations in the individual's earnings from week to week, and wide fluctuations in earnings between individuals. From this has followed the casual attitude towards the observance of agreements and conciliation procedures, as exemplified by the industry's experience of strikes, and the casual attitude militating against the efficient use of manpower, as exemplified by resistance to modern methods including mechanisation and by adherence to restrictive practices.

No great thought is required to see that all these factors and those others that follow them are detrimental to the true interest of dockworkers and employers alike. Strikes mean interruptions to earnings as well as to port operations; failure to adopt modern methods in this key section of transport damages the economy—and dockers in the major ports are now experiencing the effects of economic stricture. Irregularity of earnings breeds discontent, opportunism, and suspicion—in short it is the core of the industry's troubles. Moreover, it cannot be denied that the combined effect of the casual features of the docks industry has meant

that the industry has failed, too often, to meet the legitimate needs of its customers for service.

The National Joint Council has accordingly decided that the time has come for a fresh and bold advance towards effective decasualisation with the object of decasualising both employment and relationships in the industry.

In considering the method by which this advance should be made, the greatest regard must be paid, as in all dock affairs, to the variations in the situation from port to port. Ports in fact vary most in the degree to which they experience fluctuations in requirements for labour and these fluctuations present the greatest obstacle to solving the problems of decasualisation. In so far as these fluctuations are related directly to fluctuations in the volume of cargo to be handled they are beyond the control of either port employers or dockworkers.

It may well prove, indeed, that in some cases the fluctuations in cargo are so extreme and irregular as to make effective decasualisation impracticable at this stage, but in other ports, with comparatively moderate fluctuations in cargo to be handled, the real obstacle to more effective decasualisation has been a lack of flexibility in the deployment of labour, the remedy for which is in the hands of port employers and dockworkers, acting in co-operation.

The effective deployment of the labour force to meet a situation either of relative surplus or relative shortage of labour is inhibited by rigidity of manning scales, complexities arising from the presence on the registers of a multiplicity of employers, many of whom only engage labour intermittently but all of whom are entitled to call for labour at any time, and by restrictions on the use of mechanical aids.

To overcome these obstacles will require a profound change of thought and approach by all concerned in the industry, but they must be overcome if dockworkers are to achieve real regularity of employment and earnings and if the industry is to give the service the community is entitled to expect.

Local Joint Committees to Report

The Local Joint Committees will therefore consider the practicability of improving the present methods of dock working on the basis of the following principles:

(1) The engagement of the substantial majority of the men on the register on a weekly basis, either by individual employers or by groups of employers.
(2) Without compulsion upon any dockworker to enter into a weekly engagement or upon an individual employer to engage a particular dockworker on weekly terms, the expectation on the part of every entrant to the industry will be that he will, after an appropriate period of satisfactory service, be considered for a weekly engagement. Due regard to be paid to maintaining the balance in specialist grades.
(3) The possibility of allocation in rotation to employment of men not covered by weekly engagement.
(4) The abolition of restrictive practices including all practices inhibiting the mobility of labour.
(5) The fullest possible economic use of mechanical aids.
(6) Adoption of shift systems where appropriate, either as a general basis of operation or as the best means of deploying the labour force.

Some Uses of Photo-electric Equipment in Harbour Installations

by W. R. SHEPHERD, M.Sc.Tech., M.I.E.E.
(Engineers Department, Tyne Improvement Commission)

The photo-electric cell is by no means a new idea, but its uses can be convenient and varied within a Dock Undertaking. It is often a relatively cheap piece of equipment saving many times its initial cost by way of labour, time and materials.

Navigation lights situated up river many miles from the maintenance base, are often controlled by the conventional time switch (electrically wound) but if a power cut occurs the timing is dislocated, necessitating a special journey to correct it. In the old days of frequent power-cuts this caused such an expense that it was worth while to install magnetic amplifiers and light cells. The maintenance of such equipment over the past 10 years has been negligible, and this, coupled with the knowledge that the lights switch in and out according to the amount of daylight with unfailing regularity, has proved a source of satisfaction.

On a coal discharge plant employing wagon tipplers associated with "Beetle" type of full wagon feed, the empty wagons must run out into sidings. The oncoming full wagon is held in abeyance until the empty wagon has passed a certain point of no return. At this point the empty wagon passes through a photo cell beam which operates the relays controlling the "Beetle" driving motor. The next full wagon is then introduced into the automatic tippler gear and the cycle repeated. The de-railment of an empty wagon beyond the tippler platform thus automatically prevents the next full wagon adding to the complication, because the photo cell beam has not been broken.

Another application of photo cell equipment has recently been introduced in the two lighthouses which mark the entrance to the River Tyne.

The North Pier Lighthouse is manned continuously and the South Pier Lighthouse, being fully automatic is not manned at all.

The audible fog warning device in the former is operated by compressed air but in the latter a fog bell is rung by a balance-weight operated clapper. Inside the harbour is another but smaller lighthouse (Herd Groyne), also fully automatic and containing a fog bell mechanism similar to that in the South Pier Lighthouse.

Whilst the South Pier and Herd Groyne Lighthouses are nearly 2 miles apart and contiguous by land, it was originally found convenient to run land cables between them to a central look-out Control Tower manned by watchmen.

Across the Harbour entrance the distance over the water between North and South Pier Lighthouses is 1,250 feet and is not a good place to lay a submarine cable. In the past it has been the custom for the keeper on duty in the North Pier Lighthouse to judge when fog warnings should be initiated. To this end he would start his air compressor system and telephone (G.P.O.) to the watchman in the South Pier control tower instructing him to initiate the sounding of the fog bells in the South Side Lighthouses. The latter would do this by opening two switches in the Control Tower.

Some reference to the fog bell mechanisms is necessary at this point for a later appreciation of the part played by the new photo-electric equipment.

The fog bell clapper movement is started by the releasing of a catch normally held by an energised contactor arm. The de-energising of the contactor coil was a manual function performed by the watchman in the South Pier Control Tower. By opening two separate switches he thus started the Fog Bells on both south side

Lighthouses.

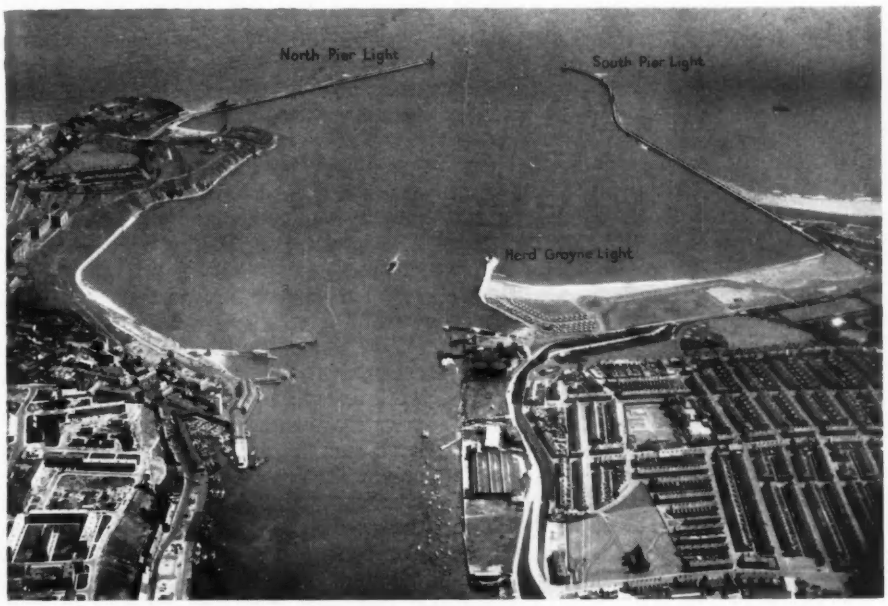
An unexpected power failure of course did the same thing automatically whether the bells were required to ring or not. The "failing for safety" feature is something to be preserved even though it entails the permanent energising of the contractor coils. On the rare occasions of power failure at unwanted times a man has to visit the contactor coil to wedge it in position.

To reduce maintenance and vibration effects the contractor coils were changed some years ago to D.C. operation via a small rectifier.

Once the contactor is de-energised the bell clapper motion is taken over by a system of descending weights. At the end of 15 minutes the weights operate a limit switch, which closes the circuit to a winding-up motor, and the cycle is then repeated. In the event of power failure during a period of use the weights travel on past the limit switch for a period of 4 hours. If power is not restored during the 4 hours then re-winding by hand is necessary—actually a very rare occurence.

For many years the Control Tower has been manned by shift men on rota. With the advent on the market of long range photo cell equipment the need for watchmen could be dispensed with, and a form of control introduced which did not require submarine cables between the North and South Pier Lighthouses.

The equipment was actually first seen on a stand at the Electrical Engineers Exhibition at Earls Court, and its possible application to the fog bell control at once appreciated.



Aerial view of entrance to the River Tyne showing position of the lighthouses.

The equipment manufactured by Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs., is designed for applications where the direct line of sight distance between the light projector and receiver units may be as great as 1,500 yards.

The light source in the projector is a simple 36 watt, 12 volt pre-focussed lamp costing 4s. 0d. having a continuous life of over 1,000 hours. A small shutter motor interposed between the lamp and lens determines the light beam frequency (modulation), and a filter ensures the infra red characteristic of the light beam. The beam cannot be seen with the naked eye at night, and so does not inconvenience River Pilots etc.

A telescopic lens fitted on the top of the projector unit facilitates initial alignment of the beam on to the receiver unit.

The projector was installed in the North Pier Lighthouse in the lamp room and connected to the 240 volt a.c. supply. A stabilising transformer ensures a constant voltage for the projector making it independent of mains fluctuations over a wide range.

Although the equipment is weatherproof and suitable for outdoor mounting, it was decided to keep it indoors for easy access. This entailed the beam having to pass through a ¼-in. thick curved glass pane without upsetting its performance in any way.

The receiver comprising a light sensitive cell with 2½-in. diameter orifice is also mounted behind curved glass in the light room of the South Pier Lighthouse. The modulated light beam is not horizontal, the South Pier Lighthouse being 36 feet lower than that of the North Pier.

The receiver unit, when energised by the beam, closes a small relay. This in turn causes a mercury delay relay to close at the end of 3 minutes. The mercury delay relay can be arranged to open an external circuit instead of closing, if so desired.

The delay relay contacts were in this case made part of the circuit controlling the contractors associated with the fog bell mechanisms, previously described.

It was a simple matter to rearrange the land cables and switchgear so that the delay relay controlled both fog bell mechanisms simultaneously although they were 2 miles apart.

Their control thus came directly under the keepers of the North Pier Lighthouse. When the bells are required to ring the keeper on duty has merely to open the supply circuit to the projector in order to lose the beam, and thus initiate the fog bells' operation.

With the mercury delay relay in the South Pier Lighthouse having a time lag of 3 minutes before it de-energises the fog bell contactor, the interruption of the beam by passing shipping is of no moment.

During a chart recording of the supply voltage variation in the South Pier Lighthouse over 24 hours, it was interesting to note the passage of sea-gulls through the beam duly recorded as well as the interruptions by ships' top structures.

It was found necessary to instal a voltage stabilising transformer in the South Pier Lighthouse to make the system wholly satisfactory.

To avoid having to replace the lamp in the projector unit at inconvenient hours it has been arranged for the maintenance electrician to renew the lamp once per month.

The annual cost of this frequent replacement (48 shillings) is cheaper than an emergency visit of a plant electrician from a distant base.

The total cost of the conversion operation came to £420, the equipment outlay being £200. The services of 3 men were dispensed with and the scheme thus paid for itself within a few months.

With regard to sizes and weights of the photo-electric equipment, the projector and receiver units will each fit into the equivalent space of a 12 inch cube and each weighs under 10 pounds. Slotted fixings facilitate initial setting up of both units, after which rigid holding down is essential.

The teething troubles were remarkably few, and the solution to mysterious odd and unwanted bell ringing was traced to the curiosity of the various North Pier Lighthouse Keepers who often wondered whether the beam was in fact doing all that was claimed for it.

Channel Crossing Controversies

Review of a Variety of Schemes Submitted

by H. J. B. HARDING, B.Sc., M.I.C.E.

It is now eighteen months since the Channel Tunnel Study Group published their report and submitted it to the French and British Governments for consideration. The recent announcement that these Governments are to discuss the Channel link has led to a fresh spate of suggestions, counter suggestions, controversies and sweeping statements. This seems a good moment to try and put the matter into some perspective.

The Channel Tunnel Study Group was formed in September 1957 and comprised the Channel Tunnel Company Limited, the Societe Concessionaire du Chemin de Fer Sous-marin entre la France et l'Angleterre associated with the International Road Federation, the Compagnie Financiere de Suez and Technical Studies Inc. of New York. The Group was administered by a Supervisory Committee of three from each element. Alternative meetings were held in London and Paris with Sir Ivone Kirkpatrick and His Excellency Monsieur Rene Massigli as Chairmen.

The Group itself consisted of men of distinction and great experience and their purpose was to put in hand joint studies on the condition in which it would be possible to build and operate a submarine tunnel for rail and/or road traffic connecting British territory with that of Continental Europe. Very early in the study an American firm of Consulting Engineers, Messrs. Parsons, Brinkerhoff, Quade and Douglas of New York were retained to study the problem of a bridge in addition to an " immersed " tunnel, prefabricated and dropped in a dredged channel and also a possible combination of the two.

The Group's first step was to appoint Monsieur Rene Malcor, Ingenieur en Chef des Ponts et Chaussees, as Delegate, with the task of directing the technical studies, both financial and engineering. The writer represented him on the British side as a Consulting Engineer in co-ordinating all the various activities.

The Report issued by the Group to the general public was a 32 page digest of the report of the Delegate to the Group. The latter brought together the salient points of all the reports submitted to the Delegate and these were expanded in Appendices and Annexures.

There were over fifteen such reports of varying content, but the following were the most important and illustrate the wide sweep of the Study and the number of eminent Consultants who took part in it.

The financial study of traffic patterns, fares, charges and tolls and also estimates of revenue was entrusted to a group consisting of the Economist Intelligent Unit Ltd., La Société d'Etudes Techniques et Economiques (S.E.T.E.C.) of Paris and De Leuw, Cather and Company of Chicago, who produced a three volume report of a thousand pages.

The vital feature of the study was the geology of the Channel and a site investigation by geophysical methods together with boreholes and sampling in the sea bed was carried out under the advice of Professor Bruckshaw, Professor of Applied Geophysics at the Imperial College with collaboration and advice from Monsieur Jean Goguel, Director of the French Geological Survey. The British Geological Survey also were a source of information.

Preliminary designs and estimates of the cost of construction and maintenance of bored tunnels, both for road and for railway were prepared in great detail by a very strong body of British and French Consulting Engineers who produced an agreed report in French and English. The firms were Sir William Halcrow and Partners, Messrs. Livesey & Henderson and Messrs. Rendel, Palmer and Tritton with Société Generale Exploitations Industrielles (S.O.G.E.I.) of Paris who also benefited by the Cooperation of Entreprise Fougerolle, Société des Grands Travaux de Marseille and Soletanche. S.E.T.E.C. carried out the general study of the terminal installation.

Relevant studies were simultaneously prepared on railway installations and operations by the British and French Railways.

Technical Studies Inc. with their American Banker associates also obtained a report from three of the leading American Contractors, Messrs. Morison Knudsen Co., Inc. Bechtel Corporation and Brown and Root. All these very experienced engineers arrived at about the same conclusions in time, cost and methods of construction.

The Reports described the design of a bored tunnel for railway traffic and also a bored tunnel for road traffic, and in the case of the immersed tube they considered an immersed railway tube, an immersed road tube and a combined immersed tube with two railway tracks and a four-way road system. In addition they discussed a bridge over the Channel and a combination of Bridge and Tunnel.

The Hyperion Group of U.S. Contractors who had carried out the immersed tube at Los Angeles using the largest de Long platform so far built had assisted Messrs. Parsons, Brinckerhoff, Quade & Douglas with advice during their Study.

They then drew in British and French associates, Entreprises Campenon Bernard and Messrs. R. Costain Limited and offered a scheme to the Delegate immediately before his report was completed and so did a group consisting of the Compagnie Francais d'Entreprise—Dorman Long Engineering Limited and Merritt, Chapman & Scott Corporation who submitted a preliminary scheme for a bridge. Their suggestions unfortunately reached the Press prematurely and so obscured the fact that both a bridge and an immersed tunnel were integral parts of the Study Group's investigations. The recommendations of the Study Group, the combination of the financial study and the engineering estimates showed that a Channel Tunnel was feasible both from the engineering and the revenue point of view.

The Governments of Britain and France are unlikely to contribute to the cost of the work and the intention is that it should be privately financed. In order to raise such a large sum it is necessary to consider not only what crossing will give the best return, but what form of crossing is within the possibilities of obtaining the finance. Consequently the conclusion of the Group was that from a technical point of view, the best means of linking Great Britain and France would be, in the first stage at least, a railway tunnel, bored or immersed which **would at the same time** provide adequate and convenient transport facilities for cars, coaches and lorries. The immediate cost was put at £109,000,000 while the bridge envisaged by their Consultants was estimated to cost £181,000,000.

The publication of the report unfortunately clashed with Mr. Kruschev destroying the Summit meeting in Paris, but in spite of this, numerous counter proposals were promptly launched. During the period which the two Governments spent in considering whether they should discuss the matter between each other, the comments became spasmodic, but have reached a fresh peak with the announcement made by the French Government that they would like to discuss such a link. This fresh interest coincides with the arguments on the Common Market. In Mr. Leo d'Erlanger's address to the Channel Tunnel

Company he pointed out that if Britain joined the Common Market, such a link would be a necessity and if we failed to join the Common Market it might become even more necessary.

Reasons for the Channel Tunnel Study Group's Conclusions

The reasons why the Group and their engineers recommended a railway tunnel are based on many considerations, but chiefly because the study showed that it would be possible to carry vehicles on special trucks through a railway tunnel at a greater volume than could be driven through a road tunnel, and at the same time the cost would be the cheapest and the yield greatest. In addition the rail tunnel would connect up a Continental system of railways with the British system. Even allowing for improvements in the reduction of exhaust gases, the problem of ventilating a road tunnel and also of the various problems of driving through it for a distance of 34 miles lead to considerable additional costs as well as the fact that the tunnel itself would have to be of a larger diameter.

The cost of a tunnel varies as the square of the diameter, so that every foot of additional width greatly increases the cost. The tunnel recommended in the Report would have an external diameter of 23-ft. 10-in. with 15-in. thick lining of in situ concrete which would result in an internal diameter of 21-ft. 4-in. or 6½ metres. There would be twin tunnels with four cross-overs, and there would be a service tunnel driven ahead and between them of about 12-ft. external diameter, which would form a means of exploration ahead of the tunnel driving, a means of carrying out injections, if required, and afterwards would serve as a means of communication, ventilation and drainage, by means of numerous cross passages.

A bored tunnel for road traffic only would need to be a minimum of 39-ft. 6-in. external diameter, but preferably 45-ft. diameter which would provide two lanes of traffic and a central breakdown lane. Thus a single road tunnel of the smallest and cheapest kind would cost 25 to 50 per cent more than a twin railway tunnel. The latter from studies made of the St. Gothard tunnel and other places has been proved to be capable of loading cars and vehicles very rapidly and being able to carry them through the tunnel at a greater rate than they could be driven.

Fig. 1 shows an artist's impression of the execution of a bored tunnel whether for road or rail.

The borings carried out on land and in the Channel produced core after core of Lower Chalk in ten foot lengths. This fact and the results of the Geophysical surveys

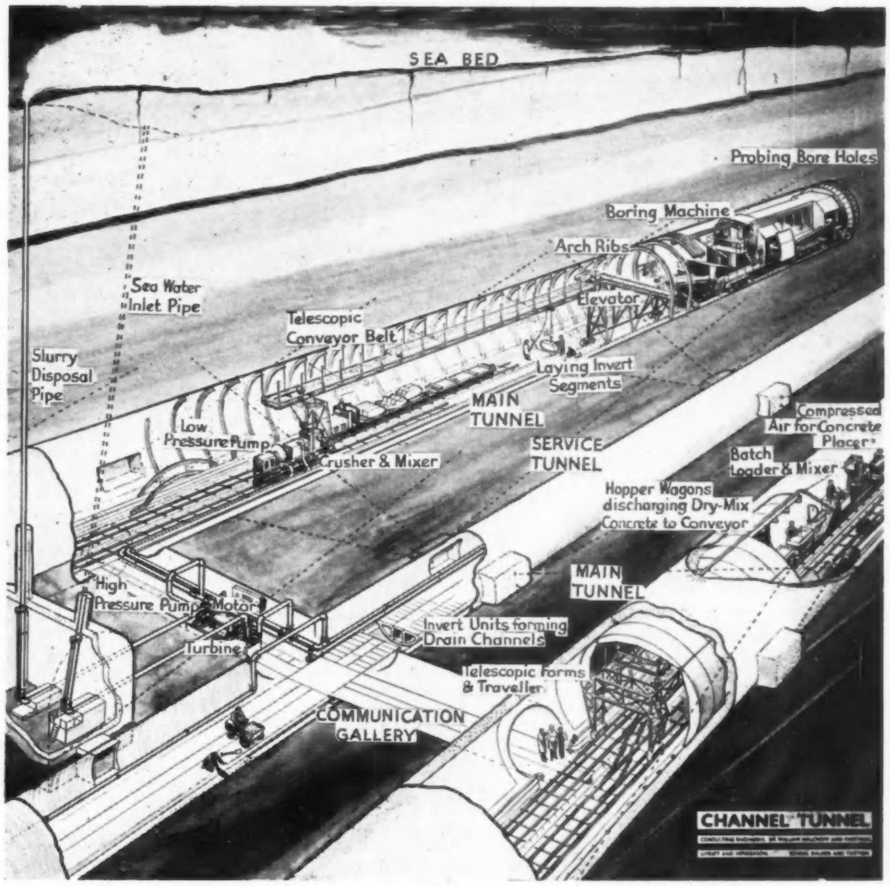


Fig. 1. Artist's impression of a bored tunnel.

which covered 900 miles together with the re-examination of the 1882 tunnel at Sangatte show that the Lower Chalk is an ideal material for a rotary boring machine and that in general does not need immediate support.

In the centre is the service tunnel which would be driven ahead by a rotary machine. Exploratory bores can be carried out ahead and laterally. These latter would be done from Chambers dug out at the sides so that tunnel driving is not interfered with. If faults are found which need injecting with cement grout or chemicals, they can be treated from the service tunnel before the main tunnel reaches the area.

On the far tunnel face (Fig. 1) is the "artist's impression" of a rotary boring machine, based on the machines used in the Oahe tunnels in Dakota, which themselves derive from Colonel Beaumont's 1882 machine and the British Price and Whitaker machines. The latter was tested at Dover in 1922.

The excavated material emerges by conveyor belt and the machine is advanced by jacks pressing against the sides of the tunnel. Ribs for support can be placed if needed in special areas, but in general no support is envisaged. The 1882 tunnels still stand unsupported after being under water for nearly 80 years. Concrete blocks are being placed in the invert as a permanent floor is needed as soon as possible. As the distance from shafts to where the tunnel's junction is 11 miles, track must be laid on a secure floor so that men and materials can reach the tunnel face quickly and safely.

The chalk is pulverised and mixed with water (as in the recent Dartford Tunnel) and then pumped out into the sea through borings shown on the left. A series of chambers would be excavated for this purpose and pumping plants would "leap-frog" past each other as the work proceeded. A second borehole brings in the water for mixing with the chalk slurry. Such bores have been made using oil-drilling techniques and precautions.

In the near tunnel can be seen the shuttering for the concrete lining and the concrete being blown or pumped into place.

Fig. 2 shows an artist's impression of a means of building an immersed tube using an outsize de Long platform. This is a novel design as the platform is not lowered to water-level as is usually the case, but is jacked forward using one group of legs and the second group is then jacked down so

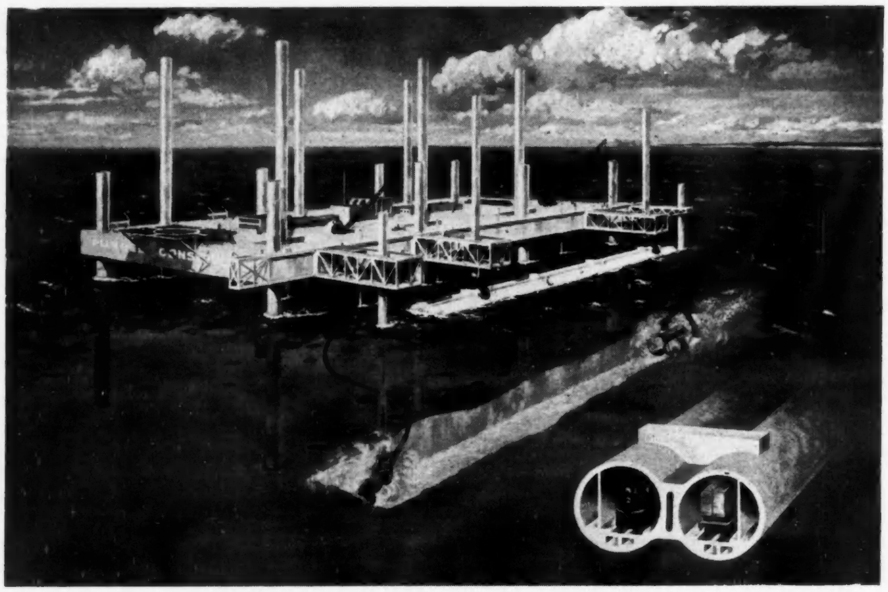


Fig. 2. This illustration shows one of the schemes put forward for laying a cut-and-cover or immersed tube using a DeLong type self-elevating construction platform designed to operate in water depths up to 250 feet. The platform is a development of the type used for off-shore drilling, radar stations, jetty constructions and other marine works where such a platform provides a working stage unaffected by winds and storms. This version is being designed to "walk" without returning to the water for floating to the next position. While supported on one set of legs it would be jacked forward and the second set of legs lowered to take the weight. The channel would be dredged from a platform and pre-cast units would be towed out and lowered into the trench. A subsequent variation suggests two platforms one for dredging and the other for laying and back filling round the units.

that the platform is always out of the water.

Since this drawing was made, the protagonists of the immersed tube have decided that two separate platforms are preferable, one to carry a rotary suction dredger and the other for laying the units.

As criticism had been levelled against the possibility of people sitting in their cars while being driven through the tunnel, an experiment was made in Paris by the S.N.C.F. Three double deck railway trucks which are used for delivering Dauphine and similar cars about the country were coupled together and attached to several passenger vehicles to add weight, and the lower decks were already filled with new cars for delivery. Various French engineers came with their own cars and these were driven up the end loading ramp and along the upper deck of the car carriages and the hand brake applied. Those who attended the demonstration were invited to fill up the seats in the cars and the train then was driven for 54 kilometres at a maximum speed of 85 miles an hour. The trip proved most comfortable and enjoyable. In one case one of the leading engineers released his hand brake and no effect was visible on the car.

Critics and Controversies

It is now possible to comment on some of the principle points of controversy and alternative suggestions which have found their way into the press, both National and Technical. The military objections to any link at all can be ignored in this article. The main conflict of opinion is bridge versus tunnel, and then that sub divides into immersed tunnel versus bored tunnel, and that choice again divides into road versus rail crossing.

As has been said above, the Channel Tunnel Study Group did not declare against any of these alternatives, but considered them all dispassionately and impartially, and after many months of thought and study by a great number of minds of experience and distinction, unanimously decided that they would propose the tunnel solution of twin railway tunnels which could not only carry all rail tunnel traffic for many years to come, but also all road traffic likely to develop.

It is interesting to note that the different protagonists are moved by different urges. The Study Group itself were concerned in finding out whether, with modern developments, such a crossing was now feasible, and if so whether it would pay, but were certainly not fanatical on the subject. They wanted to find out. If their scheme was adopted they would be in a position of clients looking for contractors, who could provide them with a satisfactory construction at a satisfactory cost.

There is another body who are very vocal in this controversy, and they are the people who have a reasonable and legitimate hope to obtain the work of construction, whether it be bridge, immersed tube, or bored tunnel. There also emerges the body of thought represented by road users of various kinds, and it becomes evident that some of these have developed what might be described as a violent antipathy to the railways. This antagonism to the very idea of committing any road transport into the hands of a railway has come as a surprise to some people. Curiously enough while the opinions vary between those who wish to abolish railways altogether and turn them into roadways to the milder persons who are merely road minded, there is a growing number of people who like to have their cars transported by rail to Scotland or across France or elsewhere, rather than endure the fatigue of driving for long distances in unattractive or over familiar surroundings.

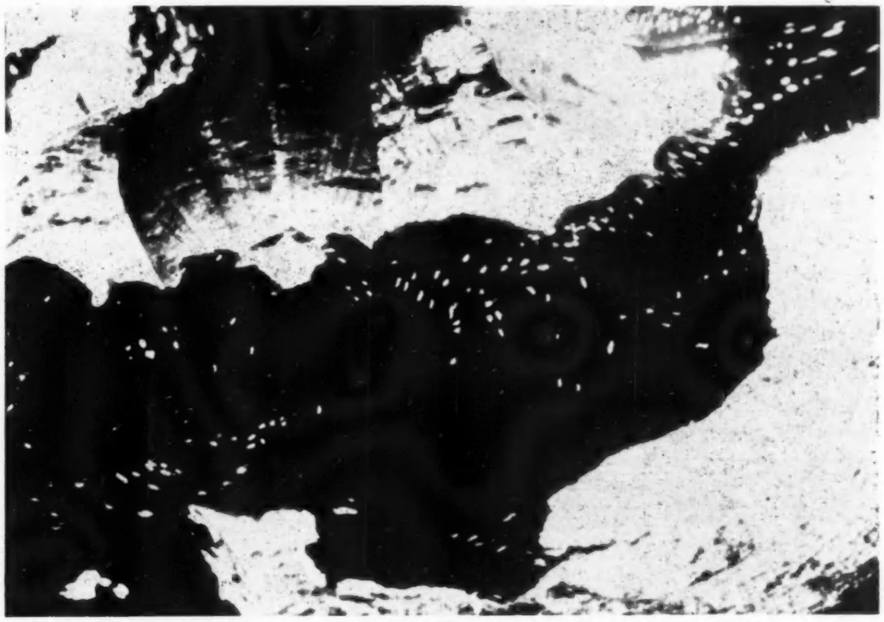
Bridge versus Tunnel

The bridge project poses a different problem. In most conditions of short crossings a bridge is always preferable to a tunnel, except where conditions make a tunnel solution necessary. With modern methods and a great deal of money a bridge could be built across the Channel. This would be an exciting engineering effort, though carrying both geological and engineering risks. Monsieur Moch has said that the construction would be "easy." Those who have worked in the Channel would prefer the word "possible."

Before considering any objections to a bridge for other reasons there is an important factor to be taken into account. The ideal would be to build it once and for all on a sufficient scale to take all possible future traffic, as the physical problems of erection would not increase in proportion to the extra width compared with the effort of building a second bridge if the first proved inadequate. However, this poses the familar problem of finding sufficient capital at the very start for a structure which could not develop its full capacity for a number of years. The alternative is only too familar with our previous road building efforts, of building too small a structure and regretting it ever afterwards.

Tunnels on the other hand could be built of unit size and it would be possible to build subsequent tunnels as developments dictate rather than having to spend a vast sum in one effort before a trend and growth of traffic can be discovered as a fact and not an assessment.

The problem of a bridge and its relation to shipping would need to be considered by impartial minds, and the first step should be to study the excellent article by Captain McMullen in the May 1961 number of "The Dock and Harbour Authority."



(Royal Air Force photograph; Crown Copyright Reserved).

Fig. 3. Radar "Mosaic" showing about 120 ships between Dover and the Casquets, bound to or from Dover/Varne Channel.

This gives radar mosaics, positions of shipping and other details which are not available to the layman, as well as a clear exposition on navigational aids. The Radar mosaic (Fig. 2) of his article (now reproduced here as Fig. 3) shows about 120 ships between Dover and the Casquets bound to or from Dover/Varne Channel. The important figure to consider is not the number of ships per day, but the "surges" of traffic, caused by the tidal nature of the London group of docks which intensifies the problem.

Vice-Admiral Sir Archibald Day, formerly Hydrographer of the Navy wrote a letter in the "Daily Telegraph" for Thursday, September 21st, drawing the same conclusions as Captain McMullen. The magic word "radar" has bemused the civilian into over estimating its capabilities. Much more would need to be heard upon the subject of the navigation problem before a bridge could be judged as acceptable. The lights of cars or the alternative described by a correspondent of a "brilliantly lit" bridge, would hardly help navigation, as the navigator is already hard put to it to keep the many lights of these busy traffic lanes under proper observation. Presumably the cost of the brilliant lighting will be included in the tolls.

One suggestion put forward that no terminals would be needed is a case of special pleading. Terminal facilities will be required whether the link is a bridge, a road tunnel or a rail tunnel carrying vehicles. Customs and Immigration will presumably continue even with a Common Market. The crossing would be at least 25 miles long. The bridge would be the equivalent of a motor way. Experience on M.1 shows the need for hard shoulders, telephones every mile and rescue squads at intervals. In addition at each bridgehead there would need to be service stations, repair facilities, restaurants and rest rooms and all the other M.1 necessities.

The Report of the Group and that of the Delegate at no time attacked the idea of a bridge. As mentioned above, le Compagnie Francais d'Entreprise — Dorman Long Engineering Ltd. and Merritt, Chapman and Scott Corporation, submitted their preliminary design to the Delegate shortly before the Report was completed. Because the project submitted by them included some very interesting new ideas, both for the spans and for the piers, which reduced the tonnage of steel, their estimate of cost was quoted in the Report although it was considerably lower than that of Messrs. Parsons, Brinckerhoff, Quade and Douglas. Probably the truth lies between the two, but in comparing the two solutions it was considered fairer to under estimate rather than to over estimate the cost of a bridge. The "Bridge Group" have since increased their own estimate.

The final report of Messrs. Parsons, Brinckerhoff, Quade and Douglas, who are one of the leading firms in the U.S.A., was received after the Group's report had been completed, but their stated conclusions are worth quoting:

"A principal advantage of a bridge crossing is the elimination of the need for ventilation, which is a particularly difficult problem in a highway tunnel. However, there are several disadvantages of an all-bridge crossing that must be considered. Among these are the following:

(a) The hazards to navigation inherent in the great number of bridge piers required; which hazards are particularly serious in bad weather. Also to be considered is the damage to the bridge structure from possible collisions with vessels. Even with the use of modern radar equipment the hazards are extremely serious.

(b) Under extreme weather conditions, the use of a bridge by vehicular traffic would be extremely dangerous, if not impossible.

(c) Maintenance of the steel superstructure of a bridge crossing would be very costly.

(d) The high construction costs for a combined two-track railway and four-lane highway bridge would undoubtedly eliminate these schemes from serious consideration as economically feasible projects.

Navigation interests might require fewer obstructions in the steamship channel areas of the crossing, which would result in longer and more costly spans."

The original scheme put forward by La Compagnie Francais d'Entreprise showed only 3 shipping lanes, with a width of 2 kilometres for the main lane. The Ministry of Transport indicated 5 lanes with 5½ kilometres width for the main lane. In the later documents the lanes have been increased, but are not the same as those indicated to the Channel Tunnel Study Group.

There is danger of oversimplification arising, and it should be the business of the navigators of all countries using the Channel to establish what spans and conditions would be tolerable.

The position of terminals proposed by the Channel Tunnel Study Group keeps traffic well clear of built up and hilly areas and adjoins road and railway. The terminals shown on the scheme for "Le Pont" do not provide for adequate connections to road and rail and considerable road works would be needed to avoid Dover, and these must be added to any estimate.

The hard fact remains that a bridge would cost twice as much as a tunnel with no greater revenue, and so the yield would not be attractive enough for private finance.

Bored versus Immersed Tunnel

The choice between immersed and bored tunnel is not really suitable for laymen to argue. The bored tunnel is a geological

risk which has been greatly minimised by modern methods of geophysical investigation and injection. The immersed tunnel is an engineering risk minimised by the development of the de Long platform which has overcome many of the difficulties of working in the sea. At Los Angeles a platform stood 6 miles out to sea in 180-ft. of water to lay 12-ft. diameter pipes on the sea bed.

It would be necessary to dredge a trench about 60-ft. wide and over 35-ft. deep and to lay the 500-ft. long units and join them up to the satisfaction of the future users. The chalk is notoriously difficult to dredge by bucket dredger, but is easily bored by rotary cutters. Colonel Beaumont's machine in 1882 bored 7-ft. diameter tunnels for a mile out to sea on either side of the Channel at an hourly progress of 3-ft. forward. Equipment on the scale required for an immersed tube has still to be designed and developed. The bored tunnel has much detailed experience behind it and rotary machines of the size required have already been used. In fact for a bored tunnel the work is roughly equivalent to the driving of two station tunnels on a tube railway and one running tunnel from each coast. The main factor would be the great length and speed of driving.

No choice can be made until estimates on a parallel basis have been examined and the immersed tube details fully worked out.

Other Suggestions

Another invention which fogged the issue was the arrival of the Hovercraft, and at once correspondents rushed into print to suggest that this completely revolutionised channel crossing. The Hovercraft has wonderful possibilities in places like the swamps of Louisiana, with its ability to ride over land or water, but as far as a Channel crossing is concerned it differs little from a ship, as it still needs to be loaded and although it has the ability to rush up the shore, considerable installations would be required for handling traffic on to it, not unlike those required in the rail and car ferries, and in the turbulent and constantly changing weather in the Channel it would surely be as vulnerable as a ship to fog and heavy weather. The size of the craft would have to be of the same order as present and future ship transports, if the Hovercraft was to make a Channel link unnecessary.

In the "Engineer" March 17th 1961, under the title of "The Channel Dam," Monsieur Rougeron set out his idea for combining a crossing with breakwaters and tidal generating stations with the hope of changing the local climate. His proposed 12½ Km. breakwaters and 15 Km. bridge is plotted in Fig. 4. This cuts across the main shipping lane to U.K. ports. This scheme must be mentioned as "The Engineer" pressed for its consideration in an Editorial in September 1961, in spite of the debatable hypothesis of M. Rougeron's theories.

There have been many suggestions for causeways with locks. The writer once spent from 6 a.m. till 4 p.m. tossing about in the train ferry steamer, inside Dover Harbour as it was too rough to enter the Ferry Dock. What would be the state of affairs if all the ships shown in Captain McMullen's radar picture attempted to enter the locks in such conditions?

The difficulty of assessing the best solution for such a vast project is increased by the propaganda of enthusiasts for one particular method, in addition to suggestions of amateur enthusiasts. One letter to the Times said that a certain argument was unanswerable. There is little in this world which is unanswerable, and the problem needs cool heads, impartial judgment, and lack of self interest. In the long run if a link is to be made, then finance must be raised and paid for out of tolls. New means of travel generate traffic and the Mersey tunnel provides a good example. The ability for trains and vehicles to cross the Channel by bridge or by tunnel does away with trans-shipment by sea or air, but it is hard to see why one form of link rather than another should generate vastly different traffic. The increase is likely to be much the same in each case, and forecasts of traffic should be made only by those who have no vested interest in any one method.

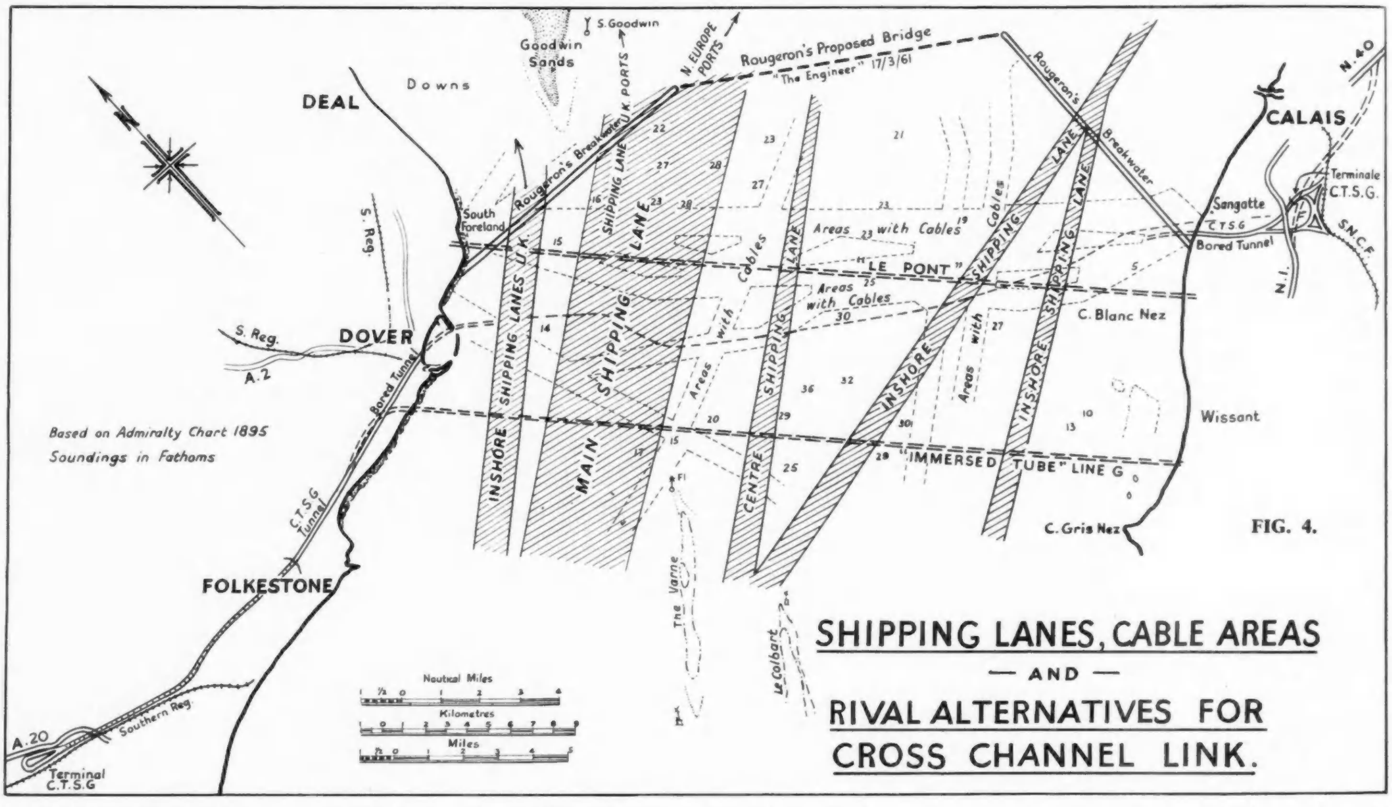


FIG. 4. SHIPPING LANES, CABLE AREAS — AND — RIVAL ALTERNATIVES FOR CROSS CHANNEL LINK.

Mourilyan Harbour, Australia

Description of Recent Improvements Effected

(Continued from Page 186)

Part III Bulk Sugar Terminal

By C. R. TRANBERG, M.I.E.Aust.

The bulk sugar terminal being constructed at Mourilyan Harbour is the fifth of such installations along the coast of Queensland, there being four terminals already in operation at Mackay, Lucinda Point, Bundaberg and Townsville. These terminals are similar in principle but vary in general arrangement and in details arising out of varying site conditions.

The production of sugar is a seasonal operation. The harvesting of the crop and the production of raw sugar by local sugar mills is carried out in the latter half of the year, that is, from about June to December. The shipping of sugar to Australian refineries and overseas, however, is undertaken throughout the whole of the year.

Consequently the requirements for a bulk sugar terminal involve not only means of transport from the mills to the port and facilities for receiving, weighing, sampling and conveying the raw sugar into the terminal and the conveying, weighing and sampling to ships, but includes storage capacity for approximately 50 per cent of the yearly production of sugar. Under ideal conditions of uniformly regular shipments of sugar from a port, the storage should be full to capacity at the end of the sugar season.

The type of storage selected is one of the most important considerations as it is the most costly part of the installation and it governs the method of input and means and rate of reclaiming the sugar for loading into ships.

The horizontal type of storage was adopted after examination of bulk handling installations for sugar and other materials in the Hawaiian Islands, North and South America, the United Kingdom and Europe, by Mr. E. G. Wagner of Macdonald, Wagner and Priddle, Consulting Engineers, and Messrs. E. M. Plomley and A. A. Waterhouse of the Colonial Sugar Refining Company Limited.

From a study of the various overseas plants it was clear that the problems associated with bulk handling facilities at Queensland ports were very similar to those associated with the Hawaiian Terminals. In both instances fast loading of ships at a rate of not less than 600-750 tons per hour was essential, and this requires a type of storage which permits of a high rate of reclamation. The latest Hawaiian installations with horizontal storage are much lower in capital cost and simpler in operation than other plants involving the use of some form of silo.

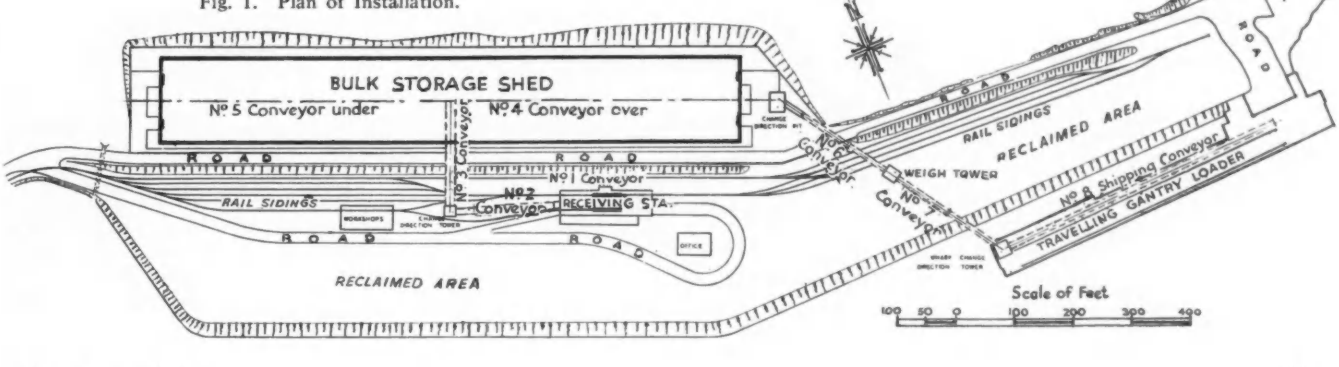
General Description of Installation

The plan of the installation, Fig. 1, shows the layout and location of receiving station and conveyors in relation to the road and rail services to the terminal and to the wharf for loading of ships. Fig. 2 indicates diagrammatically the flow of sugar through the terminal. Raw sugar from three local sugar mills, Mourilyan, South Johnstone and Goondi, and from mills at Tully and Babinda is to be handled by this terminal. Transport arrangements vary with location of mills in respect to existing transport facilities. Two mills already connected to Mourilyan Harbour by a 2-ft. gauge Queensland Government Railway will consign sugar by this means from the mills to the terminal. One mill will forward sugar direct from mill to terminal by road vehicles, and the two mills at greater distances from the port will consign sugar by 3-ft. 6-in. gauge railway to Boogan Railway Station, where it will be transferred to road vehicles for transport to the Terminal.

In all cases sugar is transported in sugar boxes constructed of a steel frame lined with waterproof plywood and fitted with fibre glass bottom linings to facilitate discharge of sugar. Each of these boxes is fitted with a top filling hatch closed by a pantograph-type rubber-sealed cover, and a side opening door is provided for releasing the sugar when the box is tilted sideways at the receiving station. The receiving station building houses the receiving hopper with a rail weighbridge at one side suitably connected to the system of railway sidings and a road weighbridge on the other side. The roof structure of the building supports overhead electric hoists of 6-ton capacity provided with travelling facilities transversely to the hopper.

In this building the incoming sugar wagons and motor vehicles are weighed, the sugar boxes tipped to discharge sugar into the central hopper and provision is made for samples to be taken of each load of sugar.

Fig. 1. Plan of Installation.



The sugar is removed from the central hopper by a steel pan conveyor (No. 1, Fig. 2) and elevated by two belt conveyors (Nos. 2 and 3) through a change direction tower to the apex of the storage shed at its centre, and then by a shuttle belt conveyor (No. 4), operating below the apex of the roof and capable of discharging the sugar at any desired position along the length of the shed.

This storage shed is 1,000-ft. long, 150-ft. wide with 17-ft. high concrete side retaining walls for storage of 16-ft. of sugar, the sugar being stored at a surcharge angle equal to the natural angle of repose of the sugar to a height of approximately 70-ft. at the centre of the shed, providing for the storage of 150,000 tons of sugar.

For loading into ships the sugar is reclaimed through a series of hoppers along the centre line of the floor of the shed, which feeds sugar to No. 5 conveyor housed in a tunnel under the floor. Seventy-six of these mild steel hoppers are provided, covering the length of the shed, and each hopper is fitted with a manually operated loading gate with an overriding pneumatic control which is interlocked electrically with No. 5 conveyor to close the gate in the event of a stoppage of No. 5 conveyor. Part of the stored sugar feeds by gravity through the hoppers to conveyor belt No. 5 and the balance is moved over the hoppers by means of two 3 cu. yd. electric shovels.

At the change direction pit, at the eastern end of the storage shed, sugar is transferred from Conveyor No. 5 to Conveyor No. 6 which elevates the sugar to the top of the weigh tower where it falls into a 10-ton hopper mounted over the 15-ton automatic batch weighing hopper. Beneath the weighing hopper is a third hopper of 20-tons capacity feeding conveyor belt No. 7. The automatic "Servo Balans" batch weigher maintains a cycle of 15-ton weighings at the rate of 50 per hour, to match the steady flow of sugar on the conveyor systems. From the weigh tower conveyor No. 7 carries the sugar to a change direction tower constructed on the western end of the wharf from which conveyor No. 8 (housed in a high-level shipping gallery) transports the sugar along the length of the wharf. The seaward side of this gallery is open to enable the gantry loader to take sugar from the conveyor from any position along the length of the gallery. A travelling gantry loader is provided, being carried on two rail tracks set in the deck of the wharf, and performs the function of transferring sugar from the conveyor in the shipping gallery into the hold of the ship.

The gantry loader is fitted with a fixed boom at the rear, supporting a conveyor and connected to a tripper on the conveyor in the shipping gallery, and with a boom capable of being lowered over the ship and carrying a telescopic tube which extends down into the hold of the ship. The gantry can travel along the wharf and the tube can be moved along the boom of the gantry to suit loading anywhere in the hatch, while the tube can be raised or lowered to suit the draft of the ship and the tidal rise and fall. At the foot of the tube is a trimmer which consists essentially of a short high speed rubber belt from which the sugar is thrown horizontally to enable the filling of hatches under the decks. The trimmer is capable of revolving through 360° in a horizontal plane.

The conveying equipment, apart from the 36-in. wide steel pan conveyor under the hopper at the receiving station, consists of rubber belts running on troughing. The incoming feed is by 30-in. five-ply belts running at 550-ft. per minute, capable of handling 450 tons per hour, and the outgoing by 42-in. wide five-ply belts operating at 450-ft. per minute and capable of handling 750 tons of raw sugar per hour. The driving pulleys are lagged and all conveyors have gravity-type take-ups except those on the gantry loader where screw take-ups are used.

Troughing idlers fitted to the conveyors are of the self-training type with troughing having a tilt of approximately 2° from the vertical in the direction of belt travel. In the case of No. 4 conveyor in the apex of the shed the troughing is suitable for moving the conveyor in either direction. Belt cleaning brushes are fitted to the head of each conveyor. In order to assist in prevention of sugar build-up on return idlers, three of these from each end of the conveyor are the open bar type.

The 36-in. wide steel pan conveyor under the hopper at the receiving station is 60-ft. 6-in. between centres and, when operating at a speed of 100-ft. per minute, has a capacity of 450 tons of raw sugar per hour. The conveyor and supporting steelwork has been designed to withstand shock loads of 4 six-ton boxes of raw sugar being unloaded together into the hopper over its full length. Conveyor chains are single-flanged roller-type 80,000 lb. minimum breaking strain running on removable manganese steel bearing strips. Removable steel pans of leak-proof design are fitted to the chains.

An interlocking system is fitted to all conveyors to prevent choking and spillage in the event of an unscheduled stopping of any conveyor, and manually reset type switches are provided on each conveyor arranged for operation by means of a pull wire system to provide for emergency stopping.

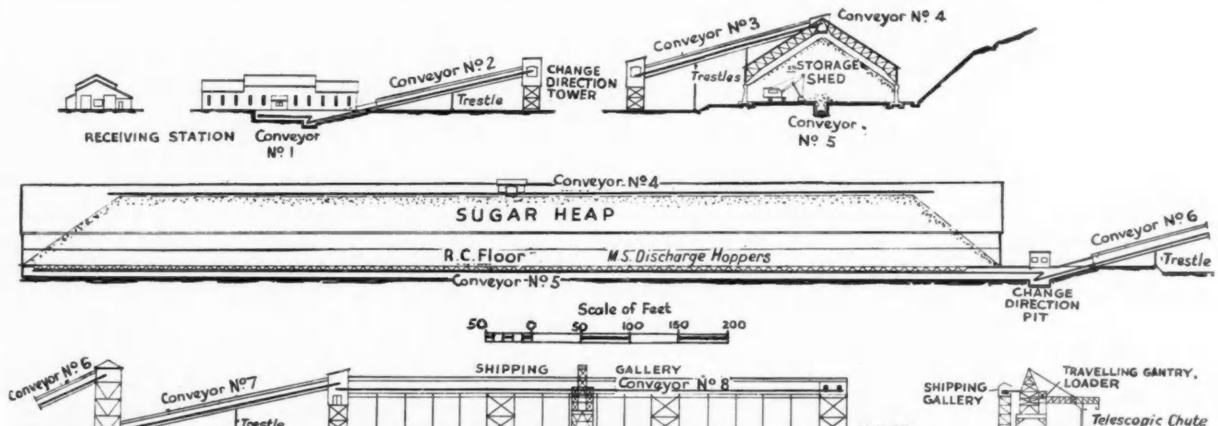
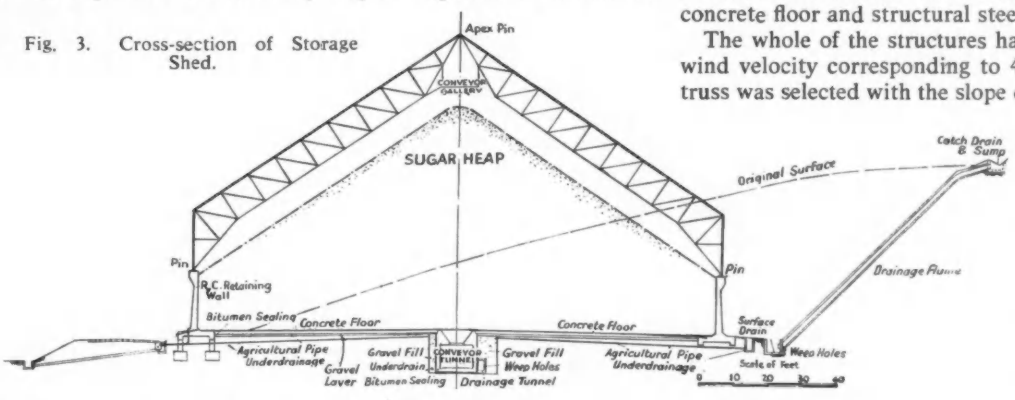


Fig. 2. Flow Diagram.

Site Considerations

The location of the terminal at Mourilyan Harbour presented some difficulty because of the extremely limited area adjacent to the harbour. Although the area was practically undeveloped, the location of the Town of Mourilyan Harbour situated along the northern foreshores of the harbour is for the most part very steep right up to the foreshore, and consists of schist rock covered by a small depth of soil with heavy tropical vegetation. Because of the limited areas available the bulk storage shed was located in such a manner that material excavated for the purpose of providing a site for the shed could be used to reclaim the foreshores for use for rail sidings, roadways, receiving station and auxiliary buildings.

Fig. 3. Cross-section of Storage Shed.



The material consists of a schist formation with quartzite bands, and it varies in hardness and quality. The formation exhibits, on the face of the cutting, folds and inclinations characteristic of this type of rock. The whole of the formation contains joint planes, some of which lie almost vertical.

It was intended to batter the side cutting at a slope of ½ horizontal to 1 vertical, but the presence of joint planes along the face of the excavation necessitated the flattening of batters to a slope of 1 horizontal to 1 vertical over most of the area.

The foundations of the shed walls and tunnel on this schist formation presented no problem and a system of pier footings was adopted for foundations in fill and on the reclaimed area. This system has now been changed to cast-in-situ piling.

It is essential that the floor of the storage shed should be dry, and the location of the shed in a site formed by excavation into the toe of steep sloping country of this nature required special consideration to be given to underdrainage to prevent seepage from the hillside affecting the concrete floor.

Fig. 3 shows in diagrammatic form a cross-section of the shed indicating the excavation and underdrainage provided. A rectangular shaped surface drain of adequate size to carry all surface water under conditions involving depositing of some material from the batters therein has been provided along the toe of all cuttings. This drain is provided with weep holes on its northern face to pick up seepage. A separate drainage channel has been provided adjacent to, and on the northern side of the conveyor tunnel in the floor and a system of unglazed earthenware drains provided under the floor of the shed itself. The reinforced concrete floor is constructed on a layer of river gravel drained by this underdrainage system. The surface of the gravel layer is sealed with bitumen before construction of the floor.

Structural Design

The adoption of the form and dimensions of the bulk storage shed followed investigation of relative costs of several sizes and shapes, and a span of 150-ft. was adopted, taking into account relative capital costs and volumes of sugar to be transferred from the side of the shed to the central hopper.

The storage shed, a cross-section of which is shown in Fig. 3, consists of reinforced concrete side retaining walls, reinforced concrete floor and structural steel roof and end walls.

The whole of the structures have been designed for 130 m.p.h. wind velocity corresponding to 42.25 lb./sq. ft. A three-pinned truss was selected with the slope of the roof following the angle of repose of the sugar heap. The trusses are spaced at 24-ft. 6-in. centres and the chords with a depth of 9-ft. are double channels, 8 x 3 top chord and 6 x 3 lower chord. The channels are spaced 6-in. apart to take the web members which are channels or tubes. It was found that all members of the trusses under one or other condition of wind loading are required to act as struts and this controlled their design. The trusses are carried on the top of the reinforced concrete retaining walls through pins carried on a base plate fitted with a shear plate grouted into a groove in the wall. The lateral thrust is distributed along the wall by means of a horizontal beam at the top of the wall.

Lateral forces from wind loading on the large areas of the gable ends of the storage shed are considerable and have been catered for by the provision of a horizontal wind truss at eaves level which transmits a proportion of the lateral force through vertical wall bracing to the side concrete retaining walls.

Vertical columns in the gable end walls extend beyond this wind truss and are provided with pin joints so as to carry as much of the lateral wind load on the horizontal wind girder as possible and reduce the amount of lateral load from the gable end to be carried through tubular struts to the roof and wall bracing. This arrangement is shown in Fig. 4. The conveyor tunnel in the centre of the floor is founded wholly upon schist rock and presented no design problems apart from precautions to keep out ground water. This has been achieved by the use of good dense concrete, rubber joints across transverse expansion joints, the use of bitumen coating to the external faces of the concrete walls and the soffit of the floor, and the provision of a drainage tunnel as described elsewhere.

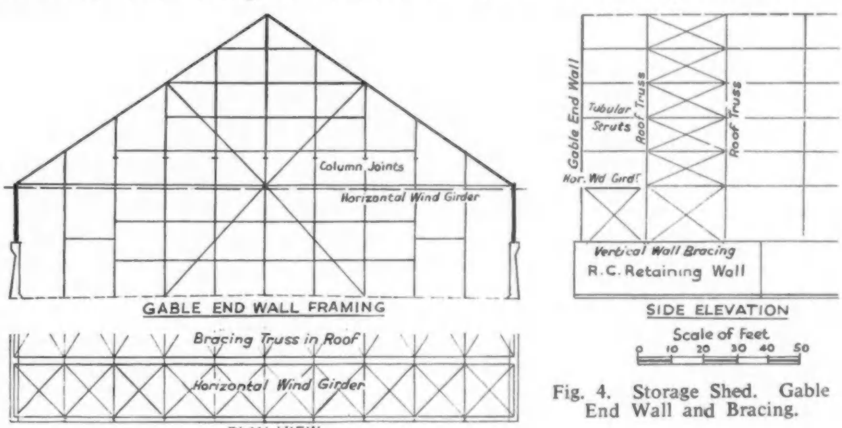


Fig. 4. Storage Shed. Gable End Wall and Bracing.

The roof and wall covering must be such as will withstand damage by hail and other weather conditions, and must be capable of sealing to keep out moisture and insulated to prevent condensation which occurs in a moisture-laden atmosphere. Accordingly the material selected was a 20-gauge corrugated galvanised sheet with asbestos felt and outer bituminous weatherproof covering which has a very long life, is structurally very robust and provides the insulation required.

This material is capable of spanning 7-ft. and this dimension was adopted for purlin spacing. Fixing is by means of hook bolts and the roof is sealed with fibre cement at laps, special bitumen filler stops at ridges, verges, eaves, top and bottom of walls and all openings. Control of air within the shed is by means of large capacity fans.

TABLE I

Test No.	Wt. per cu. ft. (lb.)	Angle of repose (degrees)	Lateral pressure per lineal foot (lb.)			
			Test result	Theoretical		
				ϕ = Angle of repose	$\phi = 33^\circ$	$\phi = 34^\circ$
1	51	38	266	218	270	260
2	53	36	290	248	281	270
3	49.75	41	263	186	266	252
4	53.75	33	258	285	285	274
5	50.75	39	251	208	267	258
6	51.5	34	251	262	273	262
7	50.75	34	259	258	267	258
8	48.75	36	272	226	258	248
9	50.5	39	270	207	268	257

TABLE II

Test No.	Wt. per cu. ft. (lb.)	Angle of surcharge (degrees)	Lateral pressure per lineal foot (lb.)	
			Test results	Theoretical (Hawken) $\phi = 33^\circ.30'$
1	48.75	Negative 35	169	182
2	50.75	„ 34	176	187
3	52.25	„ 36	169	198
4	49.25	Positive 37	453	432
5	52.75	„ 36	443	451
6	50.75	„ 35	466	421

The conveyor galleries were made wide enough to provide reasonable access to both sides of the conveyor belt with height of 8-ft. This was found to give satisfactory design of steel truss braced in sides and top with single angle chords for spans up to 70-ft. The floors are reinforced concrete, 4½-in. to 5-in. in thickness, built into the bosom of the chord angle providing a good working surface capable of being washed down and acting as a stiff plate in the plane of the floor.

The wind loading on the side of the galleries is transferred to floor level by means of a rigid frame constructed from 6 x 5 R.S.J.'s, at the end of each span. Conveyor galleries are pin-pointed to steel trestles and are fitted with shear blocks to transfer the lateral force to the trestle. Trestle bases are similarly pinned to foundations and are fitted with shear blocks for lateral loading.

The upper section of Conveyor No. 3 is carried partly on the roof structure, and this conveyor frame has been cantilevered over the trestle support at the top of the retaining wall to reduce the load carried by the roof structure.

Inclined conveyors are set at a maximum angle of 16° to the horizontal and concrete steps to suit this slope were cast integral with the floor slabs. The sides and roof are covered with deep corrugated asbestos cement sheeting on timber girts and natural lighting provided by substitution, at intervals, of corrugated perspex sheeting.

The walls are tied horizontally into the concrete floor system which is designed to take all lateral forces.

The reinforced concrete retaining walls are designed to take the lateral thrust from the three-pinned trusses at the top of the wall, and the lateral force due to the sugar retained 16-ft. high and at a surcharge equal to the angle of repose of the sugar.

A series of experiments was carried out in conjunction with the Colonial Sugar Refining Company Limited in 1948 to determine the properties of raw sugar in bulk and the lateral pressures on a retaining wall supporting this material. For the purpose of the tests a bin was constructed, 9-ft. wide with front wall 6-ft. high and higher rear wall to provide for positive surcharge to the front wall. The front wall was built in sections 12-in. wide and 3-ft. long fitted with measuring devices based on the compression of springs.

In the actual test each spring was prestressed so that the actual movement in the movable panel of the bin would be reduced to a minimum. Raw sugar from various mills with different characteristics was used in the tests, and the moisture content and chemical analysis of the sugar were recorded in each case.

Raw sugar has, under certain circumstances, physical properties involving some cohesion. However, a study of the differences in these properties in various samples of sugar and the consideration of the fact that loading was of short duration justifies the assumption of a cohesionless material for the purpose of analysis.

The mean results of these tests are summarised as follows:

Weight per cubic foot	Loose	51 lb.
	Compacted	57 lb.
Angle of repose	Maximum	41°
	Minimum	33°
Lateral pressure	Level fill	264 lb.
	Maximum positive surcharge	454 lb.
	Maximum negative surcharge	172 lb.

The shortcomings of any such experiments are well recognised and appreciated. However, they do provide information, not otherwise available, concerning the physical properties of sugar and provide a basis for adoption of a value for the angle of friction.

Individual test results are shown in Table I and a comparison is made between test results and theoretical lateral pressure using a value of ϕ equal to the measured angle of repose and for $\phi = 33^\circ$ and 34°.

The design of the retaining walls for the Storage Shed present a simpler problem than the normal one encountered in a retaining wall design, the factors contributing to this simplification being:

(1) The material to be retained is comparatively uniform and the properties can be established.
(2) The uncertainty of drainage of backfill is not present.
(3) The fact that the backfill is removed periodically, at intervals not exceeding twelve months, precludes the necessity for any consideration of long term effects.

Notwithstanding the simplification of taking the material to be cohesionless material the fact that the sugar is surcharged at the maximum angle of repose makes the use of published empirical charts unsatisfactory.

Tests carried out with maximum positive surcharge indicated, as is generally recognised, that Rankine's hypothesis for surcharged fills, yielding $P=\frac{1}{2}\gamma H^2 \cos^2 \phi$ gives too large a result for the lateral pressure P, and of course the hypothesis is inapplicable to a case of negative surcharge.

An empirical pressure diagram was developed by Mr. E. G. Wagner from the test results, resulting in an expression for horizontal pressure of $12.375H^2$ acting at $0.4H$ from base.

Lateral pressures calculated in accordance with Professor R. W. H. Hawken's[4] contention that the principal stress is vertical due to the weight of the material whether the surface is

level or at a slope to the horizontal are shown compared with test results in Table II.

The wall is a typical reinforced concrete cantilever design and can yield within the limits of deformation of the materials by retreating slightly from the filling and by a tendency to overturn about the base of the wall.

In the case of a vertical retaining wall, Fig. 5, with material retained at an angle of surcharge;

where

γ = unit weight of material retained in lb./cu. ft.

H = height of wall in feet

ϕ = angle of friction

and

θ = angle of surcharge with horizontal

and taking the plane of rupture at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ with the horizontal, the lateral pressure at any point at the plane of rupture of depth h from the surface is:

$$\gamma h \tan^2\left(\frac{\pi}{4}-\frac{\phi}{2}\right)$$

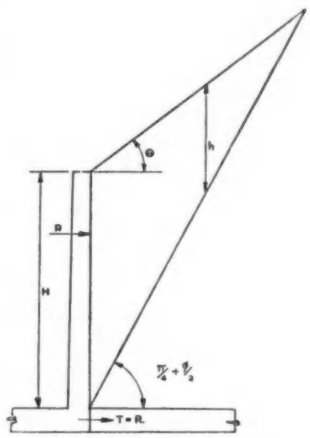


Fig. 5. Vertical Retaining Wall.

The total lateral pressure at the plane of rupture is:

$$\tfrac{1}{2}\gamma H^2 \tan^2\left(\frac{\pi}{4}-\frac{\phi}{2}\right)\frac{\cos\theta\cos\left(\frac{\pi}{4}-\frac{\phi}{2}\right)}{\sin\left(\frac{\pi}{4}+\frac{\phi}{2}-\theta\right)}$$

and this is the lateral pressure R to be taken by the wall.

Considering a wall with toe extending under the retained material, Fig. 6a, and again assuming the wall retreats laterally from the retained material, then two simultaneous planes of rupture tend to form, both at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ with the horizontal. The lateral force causing the wall to retreat can be shown to be:

$$\tfrac{1}{2}\gamma H^2 \tan^2\left(\frac{\pi}{4}-\frac{\phi}{2}\right)\frac{\sin\left(\frac{\pi}{4}+\frac{\phi}{2}+\theta\right)}{\sin\left(\frac{\pi}{4}+\frac{\phi}{2}-\theta\right)}$$

this being the horizontal component of R and equals T, the force to be taken by floor ties.

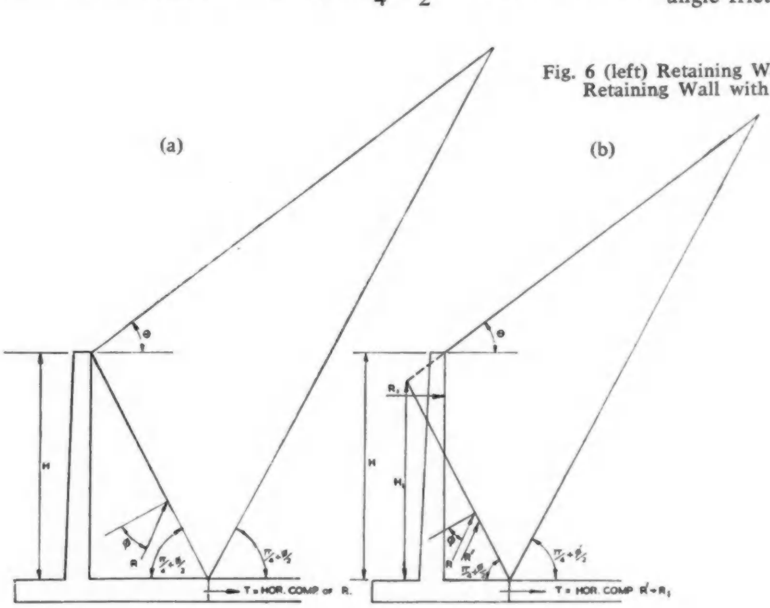
If the toe of the wall extends under the retained material so that the plane of rupture, at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ to the horizontal, extends from the toe of the wall and intersects the face of the wall, Fig. 6b, the reaction R is calculated taking the height of the wall as H_1. The thrust R_1 is applied at the vertical section of wall above the intersection of the plane of rupture with the wall and this alters the magnitude and point of application of R to R^1.

Total lateral force to be taken by floor ties is the horizontal component of R^1+R_1.

The foundation pressures to be provided for at the heel of the wall due to the sugar load can be analysed by a consideration of the wall tending to overturn about its toe, Fig. 7. In this case the whole of the material between the wall and the limiting plane of rupture CD can be considered to be in movement with parallel planes of rupture at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ with the horizontal. The reactions on the wall, R_1 either normal to the wall or at an angle δ_1 to the normal to the wall, combined with reaction R_2 acting at an angle δ_2 to the normal to the base of the wall, result in a total reaction R_3. These reactions can be calculated in terms of γ, ϕ, H, θ as before or established graphically.

Stability calculations must take into account all cases, including the tendency for the wall to overturn about the heel of the wall. In this case parallel planes of rupture at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ with the horizontal extend through the material from the face of the wall to the plane BE and the material above the toe of the wall tends to heave up. In the limit, the plane of rupture at point C would tend to commence at an angle of $\frac{\pi}{4}+\frac{\phi}{2}$ with the horizontal.

For the purposes of design, unit weight has been taken at 57 lb./cu. ft. and the sugar treated as a cohesionless material with angle friction 34° and surcharged at an angle of 37°.



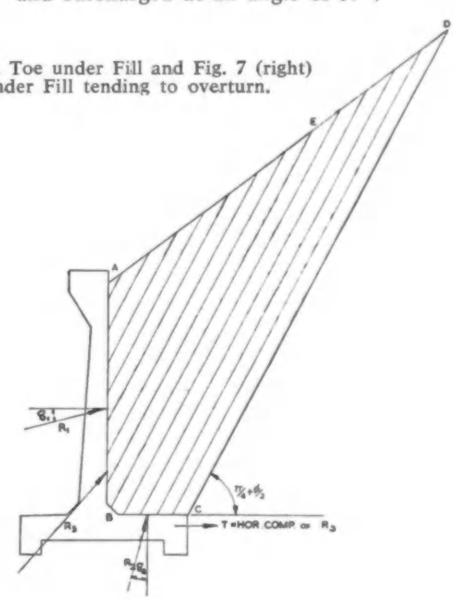


Fig. 6 (left) Retaining Wall with Toe under Fill and Fig. 7 (right) Retaining Wall with Toe under Fill tending to overturn.

The physical properties of various samples of sugar vary to some extent. The calculations made on the assumption of a uniform granular cohesionless material are conservative, inasmuch as the material has cohesive properties under certain conditions. However, the method of building the backfill, due to the method of filling the storage shed, the heap building up from the bottom of the wall in successive layers at the natural angle of repose, has to be considered and allowed for.

While the average unit weight of compacted samples of 57 lb./cu. ft. has been taken as unit weight for the purpose of calculations, it has been estimated that, at the bottom of the centre of the sugar heap under a pressure of approximately 2 tons/sq. ft., this unit weight could increase approximately 15 per cent. However, under these circumstances account must be taken of the cohesive properties developed.

While it is necessary to provide for surcharge at an angle of 37° to the horizontal the adoption of this figure for the angle of friction is not justified.

Friction between the face of the wall and the sugar can be taken into account by adopting an angle of friction δ, being some arbitrary percentage of the angle ϕ, usually from 0.5 to 0.67 ϕ. Friction between the surface of the toe of the wall and the sugar heap can only be developed to the extent that it is required.

For a surcharge of 37° to the horizontal, and adopting a unit weight of 57 lb./cu. ft. and $\phi=34°$, the lateral pressure, as calculated from the consideration of the plane of rupture as discussed, closely approximates the value obtained empirically, and the point of application of this pressure on the wall approximates to $0.4H$ using a value for angle δ of approximately $\frac{2}{3}\phi$.

Consequently, for the purposes of design the adoption of a unit weight of 57 lb./cu. ft. and $\phi=34°, \theta=37°$ is reasonably conservative. A study of the behaviour of the sugar heap in terminals in operation, through the stages of commencement of the filling of the shed, to the outloading procedure some months afterwards, seems to verify this opinion.

Of course, the effects of reactions at the top of the wall due to the roof structure and the weight of the wall itself are taken into account as well as the effects of the sugar load, in the design of the wall.

Construction

Construction work is being carried out by a number of separate contracts.

The first contract included excavation and site preparation and involved the excavation of approximately 160,000 cu. yd. of material which was used to reclaim an area of approximately 10 acres of the harbour foreshore. The cost of this work approximated 5s. per cubic yard for excavation and 3s. 4d. per cubic yard for reclamation. These costs were made possible by the use by the Contractors of heavy earth-moving equipment including heavy rippers, so that the necessity for drilling and the use of explosives was kept to a minimum.

Work commenced on the construction of reinforced concrete walls and tunnel in March, 1959, and a period of exceptionally wet weather was experienced up to the middle of September, 1959. The daily rainfall figures over this period indicate the difficulty of construction work in this extremely wet belt.

Structural steelwork is being fabricated in Maryborough and is being sand-blasted and painted before despatch to the site. Transport is limited to 40-ft. lengths of fabricated steelwork so that a certain amount of site fabrication is necessary.

A construction programme has been designed with a view to having the receiving section of the terminal ready for receipt of sugar at the commencement of the 1960 season.

Acknowledgments

The author is indebted to the Honourable the Treasurer Mr. T. A. Hiley, M.L.A., and to the Sugar Board for permission to present the paper ; to the Colonial Sugar Refining Company Limited which is responsible for the design and construction of the mechanical and electrical sections of the work and for the original conception of bulk sugar handling in Queensland and co-ordination from the industry point of view; to Mr. E. G. Wagner, B.E., M.I.E.Aust., Senior Partner, Macdonald, Wagner and Priddle, who must be credited with the overall conception and design of the Terminal, for assistance in making available his paper on Bulk Handling of Raw Sugar, Queensland, presented to the Brisbane Division of The Institution on 13th September, 1957; to Mr. B. E. Scott, B.E., A.M.I.E.Aust., and other members of the staff of Macdonald, Wagner and Priddle for assistance in checking the paper and preparation of diagrams.

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Discussion

Mr. E. I. Griffin (Member, Sydney Division)—

Part I—Mourilyan Harbour Developmental Works

My comments on this paper are directed firstly on Fig. 2 and all it implies in the handling of ships in a very tricky entrance. The method of handling the intended shipping will depend very much on the ships' draft, wind and tide, although it may be that no ships will attempt to enter or leave the port except at slack water, more on account of the narrow entrance channel than the water under the keel. It will be readily appreciated that the natural movements of a ship at light draft in strong wind will tend to be controlled by the wind, whilst the movements of a ship at full draft and in light wind will tend to be controlled by tidal currents. If it is intended to provide for ships up to 460-ft. long, and possibly over, I doubt whether a tug of only 240 h.p. could handle such ships in either of these conditions and, further can the point at which the master or pilot may drop anchor in any wise be safely predetermined as suggested? It will vary according to his judgment of the conditions prevailing at the time, particularly if a five-knot current can relatively quickly develop. The entrance is narrow at 220-ft. and seemingly a considerable amount of rock is in process of being removed—this will presumably leave a reasonable smooth dredged bottom of broken rock. Obviously no rock pinnacle can remain in the dredged channel.

The holding power of any anchor dropped on such a bottom could be negligible without the paying out of a considerable quantity of chain. With 28-30-ft. of water this could be obtained and, in the narrow confines, which must permit tug movements at the same time, this could be hazardous in the extreme. It will be more than interesting to have recorded, in due course, in the Institution's Journal the experiences gained in handling ships of the tonnage and length proposed through this very narrow entrance with its marked restriction as to overrun of the new berth, in a westerly direction.

It would also be interesting to know how far pilots will find the shore marks for "drop anchor" effective, and whether supplementary marks may be found necessary.

Concerning now the removal by dredging of some 50,000 tons of rock—this would appear to call for a bucket rather than a grab dredger. If this rock fragmentation by sub-aqueous blasting is reasonably good, no doubt a grab dredger could clean the bottom off fairly well in good time but, from experience gained in Sydney, to obtain a clean bottom free from the odd dangerous pinnacles of rock that can remain, this dredging can only be satisfactorily achieved by a bucket dredger, with an open chain of buckets. The fact that the bucket dredger "Platypus II" met with little success in that it "pushed rock forward" suggests that it might have been used in an east-west direction along the line of cut, without necessarily working to a face line. Initially, dredging across the line of channel to a face line may be difficult, but as the work of blasting proceeds, this latter movement may be possible. A close chain of buckets, if fitted to this dredger, could account for the unsatisfactory results obtained.

Turning to the wharf now being built, it is interesting to note that the flat slab type of construction has been adopted for very obvious structural advantages and future maintenance reasons. Attention is drawn to the statement of loading, under the heading "Mourilyan Harbour Wharf", given as 7-cwt. per sq. ft., whilst the diagrams in Fig. 13 give 15-cwt. per sq. ft. distributed live load. It is assumed that the lower value is the correct one, but even then it seems very high for a special purpose berth wherein the only seemingly intended loading is from the travelling bulk loading gantry. It is possible, of course, that the thickness of slab is determined rather by pile head anchorage than by live loading and that the former permits the latter. At the time of presentation of the paper I had not visited and inspected the work in progress, but on doing so found the deck slab to be 2-ft. thick, with little, to me, effective anchorage of the pile head into the deck system. This could project nearly halfway into the slab, but those I saw only projected in about 3-in. Seemingly the procedure is to cut the piles off about 3-in. above soffit level of the deck slab and weld on to each of the four 1⅜-in. main pile reinforcing bars, at about the same level, an "L" shaped bar, the longer leg being horizontal and wired onto the upper layer of slab reinforcement. This procedure does not appear to provide adequate anchorage of the pile heads into the deck slab system, and could lead to galvanic action and corrosion of reinforcement where pile and deck reinforcement systems are in contact with wire binding.

It was interesting to find that a very dry mix concrete was being used for the deck slabs, the slump being only one half inch. This, in effect, is a dry pack concrete more suitable for road work, wherein vibrators are not normally used. Indeed a dry mix such as this must surely tend to pack in patches around each point of entry of immersion type vibrators. A slump of between 2-in. and 3-in. has given very satisfactory results in wharf construction work in the Port of Sydney.

It was my privilege to visit the recently completed No. 2 Pier at Townsville and to inspect the concrete deck slab of this pier from underneath. Again a flat slab type of structure has been chosen but with a mushroom head to all piers. The piers in this case are about 2-ft. 6-in. in diameter and whilst they could not be considered as piles, they do form a reasonable basis of comparison. This type of construction, though more costly, obviously permits better conditions for transmission of moments and shears between pier, and/or pile, and slab. A similar type of construction to that used in Townsville is intended in Sydney in connection with portion of the new berths Nos. 7-9 Darling Harbour. In this design, however, ample cover between pile reinforcement and deck slab system reinforcement will be provided to minimise galvanic action leading to corrosion of reinforcement and spalling off of concrete in consequence.

Part II—Mourilyan Harbour Model

The basic object of the Mourilyan Harbour Model appears to have been a study of the effect of progressive rock removal, at the bar entrance, on silt movements within the Harbour itself, even to the point of complete shoaling. In its natural state it would appear to me from the paper that the existing natural barrier of rock provided, in effect, a submerged weir and that the tidal movements tend to move across this with little disturbance, i.e., in a translatory sense, to silt which lay in the deeper water each side of it. It also appears that on the seaward side very little soft material overlies the rock forming the bar for some distance out to sea. If such is the case, the object of the Harbour Model would appear to have been to determine whether or not progressive removal of rock would tend to a westerly flow of soft material from the seaward side, rather than the reverse. The continuous depositing of silt from the Moresby River would suggest to me that removal of the bar entrance rock would tend towards an easterly movement of silt.

The model has demonstrated that silt movement into the Harbour is small and that little change due to deepening of the entrance need be feared. This, to me, is strongly suggested by Figs. 1 and 2 and to my mind leaves little room for speculation to the contrary assuming, of course, a strong flow from the Moresby River in the wet season.

The Tidal Synthesiser itself appears to have been over elaborate for the purpose of the model and experiments. The possibility of movement of silt would seem to be dependent rather on an average tidal flow and this would appear to be the criterion of the model tests, viz., the general pattern of silt movements. The refinements entailed in the machine, which produces accurately all the variable tidal components, appear somewhat unnecessary for this particular model investigation. Extreme tides may only intensify the dominant pattern of movements.

I would appreciate comment from the author as to why such an elaborate machine was set up for this purpose and how far the refinements added any value to the conclusions reached. To me a much simpler tidal machine would have sufficed, for some two year ago I saw a good example of a simple, though accurate, model for experimental work such as described. This model was built on the job at Portland in Victoria and produced good results. The development of Portland Harbour has been the subject of a major paper in the Institution Journal.

I do, however, compliment the author for a very valuable contribution to the philosophy of Harbour Engineering, in that the many finer points presented by him will be of great value to those who specialise in this field of engineering endeavour.

Part III—Bulk Sugar Terminal

It is interesting to note that the basic wind design load for the storage shed, etc., has been taken at 130 m.p.h. velocity corresponding to 42.25 lb./sq. ft. loading. This loading appears very excessive to those of us who come from the southern States wherein the maximum basic wind velocity is generally accepted at 75 m.p.h. The S.A.A. Interim Loading Code stipulates a velocity of 110 m.p.h. north of Latitude 25° South except in special cases where 130 m.p.h. is called for. What reason, other than Code requirements, led to the adoption of this wind velocity loading? Have cyclone velocities of 130 m.p.h. been recorded in this district?

In Paper, No. 15, "Tropical Cyclones", presented later in the Conference by Mr. A. T. Brunt for the author, reference was made to a series of maximum wind velocity diagrams for varying periods of the year for the whole continent of Australia. At this stage, it is not known whether these diagrams, when published, would affect the maximum wind loadings adopted by the Stand-

ards' Association of Australia some 10 years ago as applicable to the Queensland coast if not the whole of Australia. In the light of Paper No. 15 it may be that some revision of Section 5 of the S.A.A. Loading Code will require to be made in the near future.

The author, in the latter part of the paper, has produced some interesting information on the problem of special purpose retaining walls, i.e., walls for the retention of raw sugar. This information is presented in a form that can be readily applied by those directly concerned in practical design, and, moreover, presents information hithertofore unpublished. The author is to be congratulated on the general and detail coverage of his paper.

Mr. E. C. Fison in Reply:

In answer to the comments by Mr. E. I. Griffin, it is necessary to point out that the method of handling ships in and out of Mourilyan Harbour is largely the province of the Harbour Master. The paper showed how it could be done and the final method modified by practical experience will no doubt be of interest to engineers engaged in this class of work.

The Port of Cairns, some 70 miles further north, is successfully handling vessels of 460-ft. and over with a diesel tug of 240 h.p. There are eight ports on the Queensland coast accommodating overseas ships, and of these only Brisbane and Townsville employ tugs with a b.h.p. greater than 900. Six of these ports have no tugs at all.

In the case of Mourilyan Harbour the ship will depend mainly upon her anchor. The tug will provide assistance. A well placed anchor is just as efficient as a powerful tug.

The holding ground in the harbour is very good and, as the paper shows, it is not intended that the anchor should be dropped in the dredged rock channel.

Mr. Griffin is quite sound in his opinion that excavation of rock by grab dredge is slow. It is, however, possible to use a grab dredge in conjunction with the Rockdrilling Barge. There would not be room for a bucket dredge and the Rockdriller. The present channel was deepened from 4 to 18-ft. by means of a grab dredge. The bucket dredge "Groper" will be in North Queensland early next year and it may be used to hasten the lifting of the rock.

The reinforced concrete wharf has been designed for a load of 7-cwt. per sq. ft., not 15-cwt. All general cargo wharves in Queensland are being designed to take a distributed load of 7-cwt. per sq. ft. and this wharf may at some future time be used for general cargo.

It is difficult to design the slab from purely theoretical reasons. Theory would guide the engineer to a much thinner slab. It would, however, be necessary to provide a mushroom head for the pile, with the consequent added cost of formwork.

The slab has been made deep to avoid formwork and at the same time the jetty has been given mass. Mass has two beneficial effects. It helps the structure to absorb the impact of berthing ships and it also places an initial compressive load on the piles. The piles are prestressed.

The method of marrying pile to deck slab is in my opinion adequate. The welding of the $1\frac{3}{8}$-in. dia. main pile bars to the L-shaped bars which form the bond from pile to slab has been the subject of particular attention and field examination.

Reference has been made to the transmission of shear and moment from slab to pile and I would point out that this structure is stronger than the S.A.A. Code No. CA.2-1958 and the British Standard Code CP.114. In a wharf which is provided with raker piles it is difficult to assess the moment that is being transmitted from slab to pile. The pile connection to deck slab is as strong as the pile.

Reinforced concrete wharves were first built in Queensland in 1908. I have seen no evidence of galvanic action, but would be pleased to obtain any scientically recorded information.

Dry reinforced concrete mixes have been used in piles, deck slab, and, indeed, in all concrete in the wharf. Suitable vibrators and rigid inspection make this type of concrete satisfactory and from the strength aspect very desirable. In my opinion a slump of 2-in. to 3-in. is altogether too wet a mixture for wharf construction.

Deterioration of reinforced concrete wharves in Queensland by spalling of the concrete has occurred on the underside of headstocks and girders and to a lesser extent in deck slabs.

Adequate cover over the steel together with the elimination of girders and headstocks will materially reduce maintenance of the wharf.

Mr. C. J. Apelt on behalf of Dr. G. R. McKay in Reply:

Mr. Griffin's comments are interesting, but he seems to have misunderstood a little the conclusions drawn from the model tests. He states that: "The model has demonstrated that silt movement into the harbour is small and that little change due to deepening of the entrance need be feared". As stated, this is only partly correct. The conclusion that silt movement into the harbour is small was not drawn from the model tests, but from the measurements of solid content in samples of harbour water taken over an extended period of time. The second conclusion that deepening of the harbour entrance *up to a point* will result in little change in the deep hole formation within the harbour was reached from a consideration of the first conclusion in conjunction with the results of the model tests. The model tests demonstrated the following two facts:

(i) The existence of the vertical scouring current during spring tides of the incoming tide. This current was recognised as the agency for the formation and preservation of the deep hole formation on the harbour side of the narrow entrance. It was a striking confirmation of the model's correct reproduction of prototype behaviour that the existence of this vertical current had not been suspected by those who knew the harbour well until after the model tests had discovered it and that later prototype measurements confirmed the model findings.

(ii) Deepening and widening of the harbour entrance causes the vertical current to develop on fewer and fewer occasions as the entrance cut is deepened until, with the cut at 30-ft. below low water, the scouring action develops only during the very high spring tides. Because the harbour water carries so little solid content it was considered that the occasional scouring action would be sufficient to ensure that any deposition in the deep hole formation would develop at a very slow rate.

With regard to Mr. Griffin's comments on the elaborate tide synthesiser, it is well to point out that the machine was not built specifically for the Mourilyan Harbour studies, but that it had been developed some time before hand to be used on the many different tidal model studies of varying complexity which the Hydraulics Department of the University of Queensland has conducted since 1951 and for the many which it is planned to carry out in the future. Such a tide machine will obviously be more elaborate than is required for certain specific models. This notwithstanding, Mr. Griffin's opinion that a reproduction of "the average tidal flow" would have been sufficient for the Mourilyan Harbour studies is not shared by those who carried out the investigation. Reference to what has been stated above and to Fig. 7 and to its accompanying text in Dr. McKay's paper will make it clear that *frequency* of occurrence of the scouring current is an important consideration, and this could be established only by studying the whole tidal cycles.

Mr. C. R. Tranberg in Reply:

Wind velocity for coast north of latitude 25°S for extreme conditions of exposure 130 miles per hour as set out in S.A.A. Int. Code 350 was adopted for design purposes as being reasonably conservative taking into account the location, nature of the structure and the value of the product stored in the shed.

Mr. A. T. Brunt, of the Meteorological Bureau, advises that the highest authentic wind velocity recorded on the coast was 116 m.p.h. at Bowen in 1958.

However, authentic wind velocities are available only in recent years, there being no record, for instance, of the wind velocity during the cyclone that caused severe damage in the area around Innisfail in March, 1918. Mr. Brunt is of the opinion that wind velocities up to 150 miles per hour are possible on the coast, this opinion being based on values of recorded pressures.

Mr. Brunt anticipates publication of the matter dealt with in the Paper referred to, possibly next year, but points out that the matter of calculated risk must be considered and that the adoption of the value of 130 m.p.h. for this location is reasonable.

Simple Measurement of Wave Records*

By M. J. TUCKER, B.Sc., F.Inst.P.
(National Institute of Oceanography)

When routine wave-records are being taken in order to obtain the long-term wave statistics at a certain situation, they tend to accumulate at a rather frightening rate: probably 6 or 12 a day. Though some may be subject to detailed analysis, all that is required from most of them is a measure of waveheight and period. The technique usually recommended in the past for measuring the "significant" waveheight and period was, briefly, to measure the mean height and period of the highest ⅓rd of the total number of waves in the record. It has been found by experience that the work involved in this is often sufficient to prevent it being done at all, and a quick and simple method of measurement which gives meaningful results has been devised as follows:

Measure off a 10-minute length of record, as shown in Fig. 1, and consider only waves in this interval.

Draw in a mean water-level line by eye.

Count the number of crests N_c.

A crest is defined as a point where the water level is momentarily constant, falling to either side. Some crests may be below mean water level.

Count the number of times N_z that the record crosses the zero line moving in an upward direction.

Measure the height A of the highest crest and the height B of the second highest crest, measuring from the zero line.

Measure the depth C of the lowest trough and the depth D of the second lowest trough, measuring from the zero line and taking both quantities as positive.

Record $H_1 = A + C$

$H_2 = B + D$

$$T_c = \frac{600}{N_c} = \text{period of crests}$$

$$T_z = \frac{600}{N_z} = \text{period of zero crossings}$$

The theoretical basis for this system of measurement is given by Cartwright and Longuet-Higgins (1956) and by Cartwright (1958), (see also Putz, 1954) and is briefly as follows.

The statistical distribution of wave-heights is governed by the r.m.s. wave-height $H_{r.m.s.}$ and by a spectral-width parameter ε.

From the measurements, the best estimate of ε is

$$\varepsilon^2 = 1 - (T_c/T_z)^2$$

From H_1 : $H_{r.m.s.} =$

$$\tfrac{1}{2}H_1\,(2\theta)^{-\frac{1}{2}}\,(1 + 0.289\theta^{-1} - 0.247\theta^{-2})^{-1}$$

From H_2 : $H^{r.m.s.} =$

$$\tfrac{1}{2}H_2\,(2\theta)^{-\frac{1}{2}}\,(1 - 0.211\theta^{-1} - 0.103\theta^{-2})^{-1}$$

where $\theta = \log_e N_z$

These are the best estimates to a good degree of approximation.

If these conversions were to be used a great deal, the ratio of $H_{r.m.s}$ to H_1 could easily be tabulated as a function of N_z. The statistical errors in these estimates are less than might be expected, and are not much worse than that of the mean of the highest ⅓rd waves in the records. The formulae for them are complicated, but in a typical case where $N_c = 100, \varepsilon = 0.8$, the proportional standard error in the estimate of $H_{r.m.s.}$ from H_1 is approximately 13% and from H_2 about 10%. In practice, for many civil engineering purposes, the relevant wave height is H_1, and the relevant period T_z.

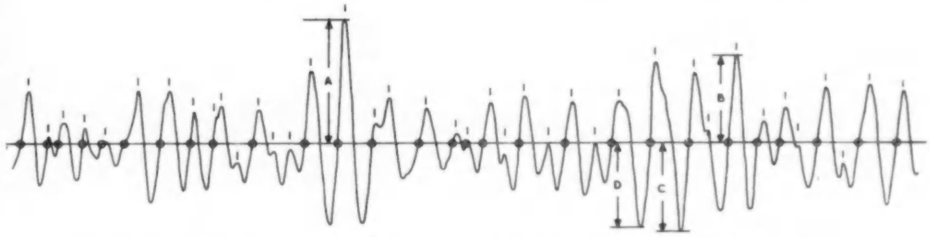

Fig. 1. An illustration of the simple measurement of a wave record (only 5 minutes of the record is shown here). The points marked with a dash are wave crests, and with a circle are zero crossings in an upward direction.

One can think of the significance of this parameter as follows. If the wave components cover a wide range of frequencies, the long waves will carry short waves on top of them and there will be many more crests than zero crossings, so that T_c will be much smaller than T_z and ε will be nearly one. If on the other hand there is a simple swell which contains only a narrow range of frequencies, each crest will be associated with a zero crossing, so that T_c will approximately equal T_z and ε will be nearly zero.

Using the measured value of ε, the values of the other waveheight parameters can be estimated from H_1 and H_2. Thus $H_{r.m.s.}$ is estimated as follows:

This system has not so far been used extensively in practice, but it is felt that it is a method of measurement which one can imagine a man actually taking the trouble to carry out, and yet which gives readings which contain all the vital information.

*The Fourth Paper presented at a Conference held at the National Institute of Oceanography, January 1961. The first three Papers were published in the Sept. and Oct. issues of this Journal. Abstracts of the Discussion on all four Papers will be published next month.

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New Zealand Dock Labour

Abstracts from 1960 Annual Report of the Waterfront Industry Commission

During the twelve months ended 31st December, 1960, the total manifest tonnage of cargo handled at New Zealand ports increased from 10,772,262 in 1959 to 11,490,341 in 1960, an increase of 718,079 tons. The relaxation of import control during the year resulted in an increase of overseas inward cargo by 564,456 tons. Overseas outward cargo increased by 20,109 tons while coastal traffic increased by 168,854 tons.

The net time rates of work for the year increased by approximately 2½ per cent as compared with last year. The gross or paid-time rates of work remained at approximately the 1959 level. This was due to further increase in unproductive time which was largely accounted for by increased delays through weather. The progressive increase in non-productive time on the waterfront over recent years shows the necessity for greater progress being made to give effect to the direction of the Waterfront Industry Tribunal for a revision of the existing cooperative contracting or incentive payment schemes to provide a real incentive to workers to reduce delays. This revision will only be successful if it is brought about with the full cooperation of port unions and workers. It is therefore essential that any revised scheme is fully understood by the men and they obtain the benefit of increased bonuses through the saving of delays to shipping. Some of the delays to shipping ,e.g., awaiting cargo, shortage of equipment, etc., are the responsibility of the employers and shipping companies, and harbour boards should take steps to reduce these delays to a minimum.

Very serious congestion of shipping occurred at New Zealand ports at the end of the year. This was due to—

(a) A substantial increase in overseas imports and the termination of the import licensing period at 31 December coinciding with the closing down of the merchant stores over the holiday period.

(b) Congestion of wharf and railway goods sheds brought about through the working of ships over a span of not less than 59 hours per week, while the delivery of goods from wharf and railways goods sheds is made for a period of less than 40 hours per week.

The recent decision of the Government to change the import licensing year from 31 December to 30 June will go a long way towards avoiding congestion of shipping at the end of the year. There will, however, be occasions in the future, whether through strikes or otherwise, when there will be congestion of shipping at the ports and it does appear that some additional legal machinery is necessary to assist harbour boards and Railways Department in preventing or reducing the congestion in wharf and railway goods sheds to minimise the delays to shipping. This matter is under consideration by the Government.

The Tribunal increased the ordinary time rate of pay to 6s. 9d. per hour, granted full incorporation in contract rates of the 24 per cent wage increase made from 4 January 1960 and improved other conditions of employment. The total benefits granted to the workers under the new general principal order were estimated to cost £346,000 per annum or £1 1s. per man per week. The total benefits obtained during the year through incorporation and under the new general principal order were estimated at £541,000 per annum or £1 12s. 10d. per man per week.

The average weekly hours for all ports (including the hours paid for annual and statutory holidays and daily and weekly guarantees) increased by one and one-quarter from 45½ hours in 1959 to 46¾ hours in 1960. The average weekly wage increased from £21 0s. 3d. in 1959 to £23 11s. 2d. in 1960, an increase of £2 10s. 11d. per week.

The increase in contract rates granted by the Tribunal as from 23 May 1960, together with the increase in net time rates of work and increase in tonnage handled during the year, resulted in an all time record in bonus payments under the Commission's cooperative contracting system. The total bonus paid during the year was £1,268,577 at average rate of 2s. 2·56d. per hour as compared with £1,001,718 at average rate of 1s. 10·75d. in 1959. Payments made under employers' incentive schemes increased from £86,656 in 1959 to £116,448 in 1960.

There was only one industrial dispute involving a stoppage of work on the waterfront during the year. This occurred at Wellington and was a breach of the written undertakings given by all registered waterside workers to accept the principle of conciliation and arbitration in the settlement of disputes and resulted in a loss of 12,160 man-hours and £7,765 in wages.

Everyone associated with waterfront work should be concerned at the very high accident rate in the industry. From the total of 6,412 men on the bureau registers at all ports 1,675 men, or 25 per cent, were absent during the year on compensation through accidents. Some of these men were absent for more than one accident. The time lost of 337,155 man-hours represents a loss of 52 man-hours, or approximately seven working days for each registered worker in the industry as compared with the loss of 12,160 man-hours or two man-hours per registered worker through stoppages of work on account of industrial disputes.

The efficiency of the waterfront industry is largely dependent upon the maintenance of good industrial relations between employers and workers, the full appreciation by the workers of their contracting or incentive payment system and the employers exercising adequate and continuing supervision to ensure that the men work the full hours for which they are paid. There was some deterioration in industrial relations between employers and workers during the negotiations for the new general principal order. It is pleasing to record, however, that harmonious industrial relations have now been fully restored. Waterside workers enjoy good conditions of employment and by cooperation with the employers to improve the efficiency of the industry those conditions can be further improved.

Income and Expenditure.

Total income for the year ended 31 December 1960 was £1,327,351, an increase of £300,752 on the total income of the previous year. There were increases in income from levies (£281,745), canteen receipts (£8,811), and assessments—Port Union Stevedoring Fund (£10,943), and a reduction of £747 in sundry income. The levies for the year ended 31 December 1960 represents 87·39 per cent of total income as compared with 83·54 per cent in the previous year.

The total expenditure of the National Administration Fund for the year ended 31 December 1960 was £1,145,399, an increase of £166,691 on the total expenditure of the previous year. General expenditure increased by £30,614 and the increase in waterfront wages expenditure was £136,077. The principal increases in general expenditure were in respect of canteen operating expenses (£5,527), depreciation (£1,602), printing and stationery (£3,357), salaries, etc. (£14,682) and sundries (£3,199).

The General Revenue Account for the year ended 31 December 1960 shows a credit balance of £181,952, which is an increase of £134,061 as compared with the previous year.

Interest from investment of reserve funds amounts to £24,026, a reduction of £5,624 as compared with 1959. After allowing for debit adjustments totalling £1,115, there was a total of £204,863 available for appropriation.

Rubber Fenders for Piers and Docks

Details of Some Recent Installations

By A. R. SMEE, C.B.E., M.I.C.E.

By kind permission of the author and the National Rubber Bureau, we published in the January 1961 issue of this Journal, a review of developments during the last decade in the use of rubber in pier and dockside fenders. We are now printing in this issue the concluding article in which the Bureau's Engineering Consultant describes some recent installations.

Dagenham Dock

In the 1954 Spring edition of Rubber Developments four different rubber fender systems were described which Samuel Williams and Sons Ltd. had installed at Dagenham Dock on the lower reaches of the Thames. Subsequently a further type of fendering in the shape of rubber cushioned floating booms was designed by Mr. D. C. McCormick, the Deputy Civil Engineer, and has been in service for the past five years on Jetty No. 4.

Lines of these booms are employed on both sides of the jetty but those on the river side, where ships of up to 15,000 tons berth, are of rather heavier construction than those on the shore side of the jetty which caters for barges of up to 500 tons capacity. Both are, however, to the same design and operate on the same principle.

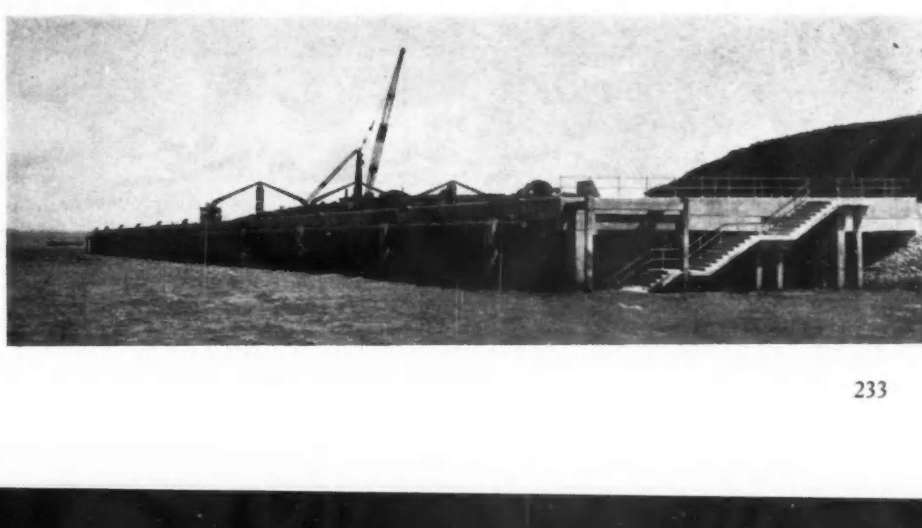
At the time of our visit to Dagenham Dock the seaward berth of the jetty was occupied by the "Ingwi" of Bergen, a modern all-welded ship of some 13,000 tons, and as this proved rather an obstruction, the photograph at Fig. 1 was taken of the rather lighter, but otherwise identical, booms on the inshore face of the jetty. These serve to illustrate their construction and method of location.

The main beam of each boom is some 40-ft. long and, on the seaward side, is of 16-in. x 16-in. cross section Douglas fir. Heavy timber brackets projecting rearwards near either end of the beam locate it between vertical timber fenders, and a projection at the end of each bracket engages against the rear of the vertical fenders and restrains the boom from floating outwards.

The suspended vertical chains seen passing down through the timber brackets are a security measure to ensure that should a boom ever get broken it will not float out into the river and endanger traffic.

Fig. 1 (above). Floating booms at Dagenham Dock. Rectangular rubber fender sections can be seen attached to the inshore faces of the booms near each end.

Fig. 2 (below). Front of Berth No. 11. Mombasa Harbour, looking west



Near the extreme end of each boom and attached to its rearward face is a short length of Goodyear rectangular rubber fendering and this bearing against the vertical timber fenders provides the cushioning medium. The timber fenders are in turn cushioned by similar rubber sections located between them and the jetty.

As the main beam itself is possessed of some resilience and is rubber cushioned against the vertical fenders which are themselves rubber cushioned against the main structure, a high degree of protection is given to vessels berthing at the jetty in the comparatively sheltered waters where Dagenham Dock is located.

Mombasa

Designed for ships of some 20,000 tons displacement such as the "Kenya Castle" and sister ships of the Castle Line and the "Uganda" and "Kenya" of the B.I. Line, four new berths totalling some 2,400-ft. length are projected for Mombasa Harbour. Of these, two berths are nearing completion and will be operative in early 1961.

The photograph at Fig. 2 shows the general arrangement of one of these berths which are to the design of Messrs. Coode and Partners, Consulting Engineers, of Victoria Street, London, and Figs. 3 and 4 reproduced from the working drawings illustrate the system of fendering employed.

Arranged at 60-ft. centres each fender unit consists on its seaward face of three 12-in. x 12-in. greenheart timbers 14-ft. long arranged vertically and bolted on to steel joists and channels in turn welded on to a group of four Peine piles driven down into the shale sea bed. At their upper end the

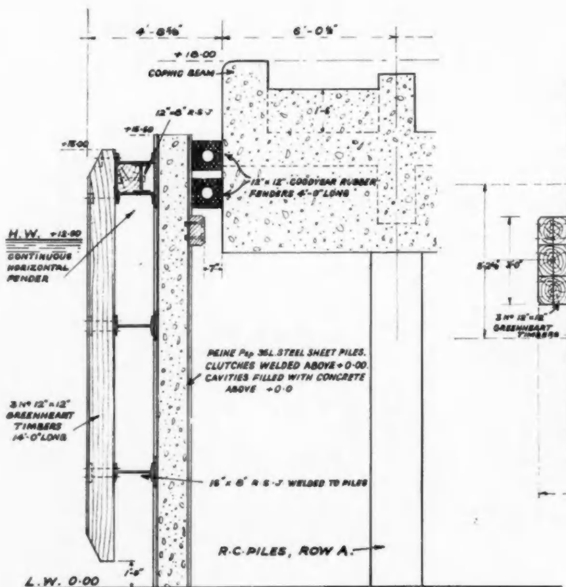


Fig. 3. Sectional elevation of main fenders on Berth No. 11, Mombasa Harbour.

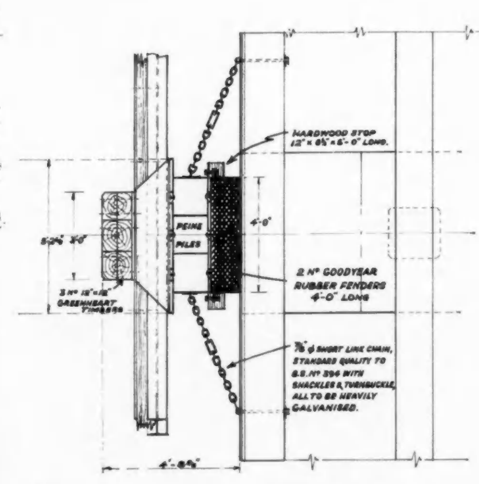


Fig. 4. Plan of main fender.

Peine piles back on to duplicate lengths of Goodyear rectangular rubber fendering 12-in. x 12-in. x 4-ft. long arranged horizontally and bearing against the concrete coping beam of the jetty.

Permissible compression of the rubber sections is limited to 7-in. by a hardwood stop and, based on the energy-absorbing capacity of the rubber, the fender system is adequate to damp out the thrust of a 20,000-ton ship making a side-on-approach at 0·5-ft. per second. Lateral movement of the fender unit is prevented by the anchorage chains shown. As the berths are in an enclosed harbour wave action does not present a problem.

To ensure protection to smaller vessels using the berth the horizontal waling at the top of the fender unit, consisting of a 12-in. x 12-in. greenheart timber bolted to a 12-in. x 8-in. R.S.J., runs the whole length of the berth and is attached at 20-ft. centres between the main fenders to intermediate fender units each consisting of a single Peine pile backing on to a vertical Goodyear rubber section 12-in. x 12-in. x 1-ft. 6-in. long. The plan view at Fig. 5 shows the arrangement quite clearly.

Fremantle

Fremantle lies a few miles south of Perth on the south-western seaboard of the vast Australian continent and serves a hinterland some 300 miles deep and about 50,000 square miles in extent.

Situated at the mouth of the River Swan the port is sometimes called the Western Gateway to Australia and it is the first or last port of call for ships from or to Europe, South Africa, America via Suez, or to India or South-Eastern Asia.

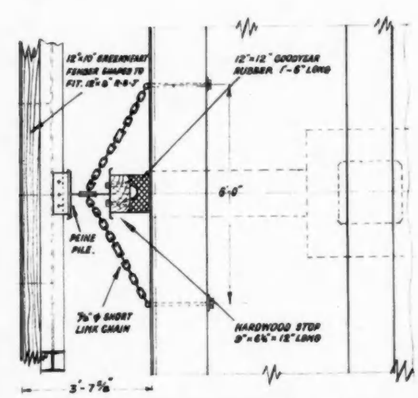


Fig. 5. Plan view of intermediate fenders on Berth No. 11, Mombasa Harbour.

Covering the enormous area of 180 square miles the port comprises an inner harbour with 18 deepwater land-based berths capable of handling ships up to 45,000 tons, all completely equipped for the handling of bulk and general cargo and with road and rail facilities; and an outer harbour which includes three main anchorages — Cage Roads, Owen Anchorage and Cockburn Sound. Development of the port is unceasing and its vast potential for future expansion permits the Fremantle Harbour Trust, the ruling body, to implement an avowed policy of keeping ahead of the ever-growing requirements of the State as regards the handling of cargo, the movement of passengers and the provision of bunkering facilities.

A modern requirement for modern ports is adequate protection for the ships as they come in to berth and while tied up alongside, and it is not surprising that at Fremantle rubber fenders figure on new construction work Fig. 6 shows an arrangement of Dunlop tubular fender sections installed on a jetty under construction for smaller craft within the inner harbour. The layout could hardly be more simple—a row of free standing timber piles to which are bolted heavy horizontal walings to distribute the load and the whole framework cushioned by rubber fenders each 36-in. long x 10-in. outside diameter and 5-in. bore attached along the jetty face behind each vertical pile. Suspension of each section is by through bolt held at either end by short lengths of chain in turn bolted to the jetty. with the natural "spring" inherent in the timber piles, backed in effect by rubber buffers, good protection against shock is provided for both ship and structure.

Dunlop fender sections are also being employed at Fremantle on the new Passenger Terminal and are in use at 15 other ports throughout Australia, including Port Melbourne, and Hobart, the capital of Tasmania.

Bluff Harbour

Situated on the south coast of South Island, New Zealand, Bluff Harbour has recently been considerably enlarged to enable it to keep pace with the demands caused by the ever-increasing export and import trade of the prosperous and rapidly-developing province of Southland. Predominantly agricultural, Southland is one of the world's large sheep and cattle rearing

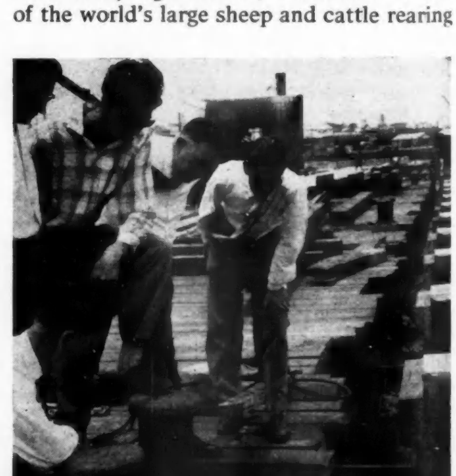


Fig. 6. Arrangement of Dunlop rubber fender sections at jetty in the inner harbour, Fremantle.

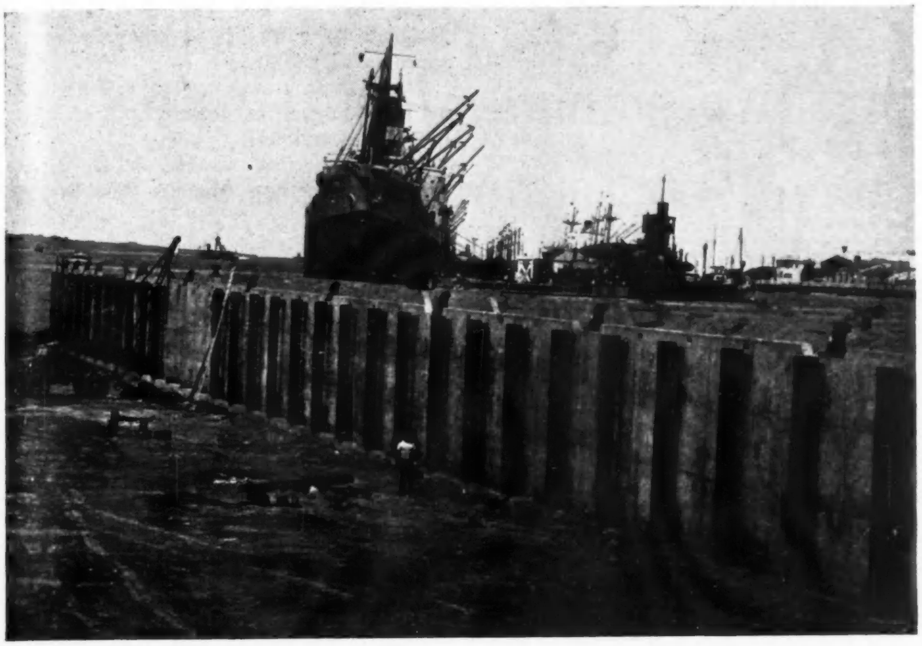


Fig. 7. Fenders being installed at Bluff Harbour, New Zealand.

areas and provision is included in the new project for the most modern all-weather loading facilities for the export of meat.

The Harbour Board's Chief Engineer, Mr. D. E. S. Mason, was responsible for the design of the entire project which includes for three wharves, each 700-ft long, to accommodate ships of up to 33-ft draught and two wharves, each 525-ft. long, dredged to take vessels up to 24-ft. draught. Fig. 7 shows one of the berths under construction and incidentally gives a good idea of the busy trade of the port.

Designed for vessels of 20,000 tons with an approach speed of 0·5-ft./sec. the fender system is based upon tubular rubber sections in axial compression. As can be seen from the above photograph, there is, at the foot of the jetty wall, a protecting concrete shelf. Standing on this, on steel base plates, are vertical hardwood timbers spaced at 15-ft. centres and built into a solid framework by heavy horizontal timber walings.

These vertical timbers are secured to the wharf face by chains top and bottom and so arranged that in and out movement of the timbers is permitted. The rubber buffers are held in position by pairs of cast steel spigots, one bolted to the vertical timber. The diameter of the spigots is such that it fits tightly in the bore of the rubber buffer and the thickness is sufficient to avoid excessive compression on the buffer. Fig. 9 illustrates the arrangement quite clearly and Fig. 8 shows a general view of the whole fender assembly.

Lateral movement of the fender frame is restricted by the chains fitted at the top and

Fig. 8. General view of fender assembly at Bluff Harbour.

by steel shoes fitted to the supporting concrete projection.

The rubber sections employed were manufactured by Reid New Zealand Rubber

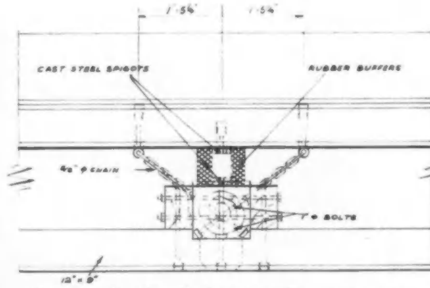


Fig. 9. Sectional plan showing arrangement of rubber buffers at Bluff Harbour.

Mills Ltd. and are all 10-in. long with a 5-in. bore and are 12-in. in outside diameter on the wharves catering for the largest ocean-going ships and 10-in. diameter on these where smaller vessels will berth. Clauses dealing with the provision of these rubber buffers specify "When the buffers are subject to an end compression test the load to compression ratios shall be such that at 50% compression the load shall be at least 600 lb./sq. in. of original section and at 60% compression the load shall be at least 1,200 lb./sq. in. of original section." A further clause requires that "one in every 10 buffers shall be tested in end compression and one in every 50 buffers shall be given 50 cycles of compression of 60 per centum."

With its deep water berths, a fender system designed to obviate damage to ships while moored, and equipped with most modern cargo handling facilities, Bluff Harbour must obviously make a considerable contribution to New Zealand's expanding economy.

Port Swettenham—Malaya

A fender system employing somewhat

Fig. 10. Wharf No. 3, Port Swettenham, Malaya.

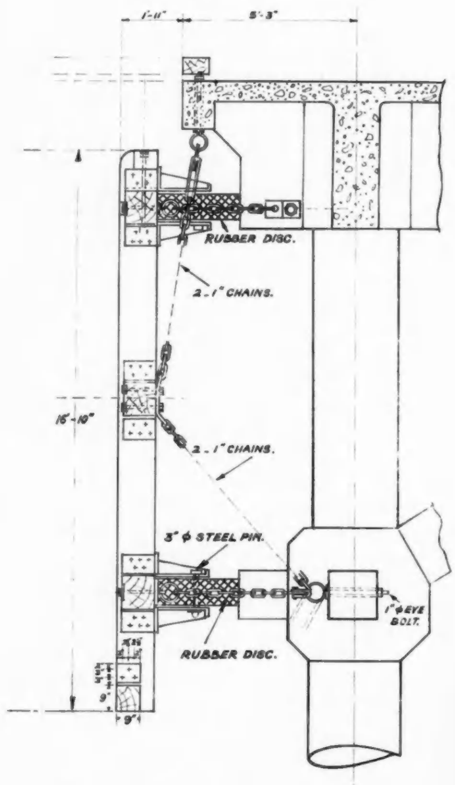


Fig. 11. Sectional elevation of fender system at Port Swettenham.

novel rubber units has been installed at Wharf No. 3—Port Swettenham.

Situated on the Klang River in Selangor Province, Port Swettenham has a fairly close road and rail communication with Kuala Lumpur, the capital of Malaya, and is in process of considerable development for both ocean-going and coasting vessels.

Wharf No. 3 is an extension of existing wharves Nos. 1 and 2 formerly known as the Coastal Wharves, the whole design and construction being carried out by the Malayan Railway Civil Engineering Department.

Of reinforced concrete 350-ft. long and 37-ft. wide, the wharf is designed to take rail traffic and 5-ton cranes, and with a depth of water alongside of 23-ft. at low tide it can accept ships of up to about 5,000 tons.

Fig. 10 shows a general view of part of the wharf and gives a good idea of the fender system used. Heavy 14-in. x 14-in. vertical timbers are spaced at 16-ft. centres along the jetty face and top and bottom at the back of each timber is a pair of brackets carrying a rubber disc 30-in. in diameter by 9-in. thick which bears upon projections in the concrete structure. Fig. 11, Fig. 12 and Fig. 13 show the arrangement quite clearly.

The vertical timbers are connected by horizontal walings forming a continuous framework which is suspended by chains as

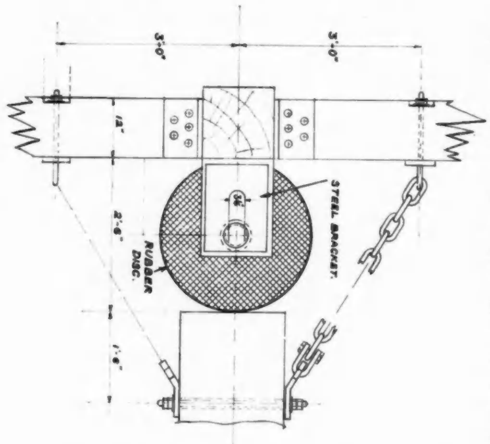


Fig. 12. Plan view of fender system at Port Swettenham.

shown, while horizontal chains top and bottom of each vertical timber restrict any lateral movement.

The rubber discs were manufactured

Fig. 13. Close-up showing mounting of rubber disc at Port Swettenham.

locally by the Bell Co. Ltd., and are designed to allow for a compression of approximately 10-in.

The extension was opened in July 1960 by the Minister of Transport, The Hon. Inche Sardon bin Haji Jubir.

We are indebted to Mr. A. D. Eaton, Chief Civil Engineer, Malayan Railways, for these details.

Conclusion

The examples of fender systems described in this and the preceding two articles cover, of course, only a fraction of those in service but it is hoped that they are sufficient to convey a fairly good idea of the current trend of design and to illustrate the adaptability of rubber to the requirements of the engineer.

In conclusion it would not perhaps be out of place to have one very brief look at the other side of the picture—at the fenders (or fend-offs) carried by smaller vessels, tugs, trawlers, workboats and the like. Festoons of old tyres may—and indeed do—provide a good measure of protection but their decorative value can only be described as decidedly negative—a trim craft surely deserves something better than to be plastered all round with salvage from the scrap heap—and something better is readily available.

Rubber mouldings in a variety of shapes and sizes can be obtained for attachment to stem or quarters and, if required, can be tailor-made to ensure a perfect fit. Extruded or solid-rubber sections can be employed either as a continuous fender along the length of the vessel, or as a built-in rubbing strake while a wide range of neat looking pendant rubber fend-offs afford ample choice for craft of all sizes.

Whether protection is required for the giant 100,000-ton tanker or the flimsiest of racing dinghies, rubber with its unique properties will do the job—and do it well.

Fig. 14. Better looking than old tyres and much more effective. Clyde Pilot cutter Cumbrae fitted with rubber fenders made by North British Rubber Co. Ltd.

Planned Maintenance with an Incentive Bonus Scheme at Newport Docks

By W. SHAW EVANS, A.M.I.Mech.E., A.M.I.E.E.
(British Transport Commission, South Wales Docks)

The installation of a system of planned maintenance is the dream of most engineers responsible for the maintenance of an installation, but many, after a superficial examination of the facts, conclude that the probable increased cost of maintaining the necessary records and the additional staff necessary to carry out the increased maintenance (if such staff are available) cannot be justified economically. Also, they feel that they have insufficient time at their disposal to plan and install the new organisation required.

The application of work study techniques to engineering maintenance can provide planned maintenance at no additional cost, without requiring additional staff and, also, if specialist work study staff or consultants are employed, without making excessive demands on the engineers' time.

This article describes the introduction of a system of planned maintenance with incentive bonus based on work study in the Mechanical and Electrical Engineer's Department at Newport Docks (Monmouthshire).

Newport Docks

Newport Docks is a modern general cargo port on the Bristol Channel, having a water area of 125 acres (Fig. 1). It is provided with some 55 electric cargo cranes of 3-ton or 6-ton capacity, ten 10-ton four-line grabbing cranes, a considerable number of diesel electric mobile cranes, battery-operated fork-lift trucks, floating cranes, etc. A high-voltage electricity distribution system, having a maximum demand of some 4,500 kW with an annual consumption of 17·5 million kWh, supplies the electrical requirements of the cranes, dockside tenants and two electrically driven hydraulic pumping stations, one of which also houses two impounding pumps of 700 h.p. each for maintaining the level of the dock. The hydraulic power operates six coal hoists, a lock-gate installation and swingbridge through a hydraulic main network. The principal imports of the port are iron and non-ferrous ores, timber, petroleum, iron and steel goods, etc., the annual tonnage imported being 1,500,000; the principal exports are coal and coke, tinplate, iron and steel goods, etc., the total tonnage handled annually being 1,000,000.

The port forms one of the five Bristol Channel ports of the South Wales Docks group of British Transport Docks and the mechanical and electrical engineering installations are the responsibility of the Mechanical and Electrical Engineer, South Wales Docks, whose headquarters are at Cardiff, some 16 miles away.

Maintenance Staff

The maintenance personnel at the port are under the control of the Dock Engineer (Mechanical and Electrical), who is responsible for the day-to-day running and organisation of the port maintenance and for the carrying out of new work projects of a limited nature.

Originally, maintenance work was organised by splitting up the dock into numerous geographical areas and allocating to each a chargeman and a number of craftsmen and mates, each chargeman being responsible for the inspection and maintenance of the equipment in his area. Much of the maintenance work carried out was of a breakdown repair nature rather than preventative maintenance, and considerable overtime working was necessary to maintain the appliances in commission or available for use on the following day.

Planned Maintenance

In 1957 the Mechanical and Electrical Engineer, faced with the problem of staff shortages and a projected unprecedented demand for labour in the area due to new factories commencing production, decided to investigate the possibility of introducing a scheme of planned maintenance coupled with incentive bonus based on work study at the port, and the author was, after formal training in work study, appointed to undertake the work. It was agreed with the staff representatives at the time that all recruitment would cease in order to ensure that staff economies effected by work study would not lead to redundancy, any shortage of staff due to natural wastage during the period of the investigation being met by overtime working.

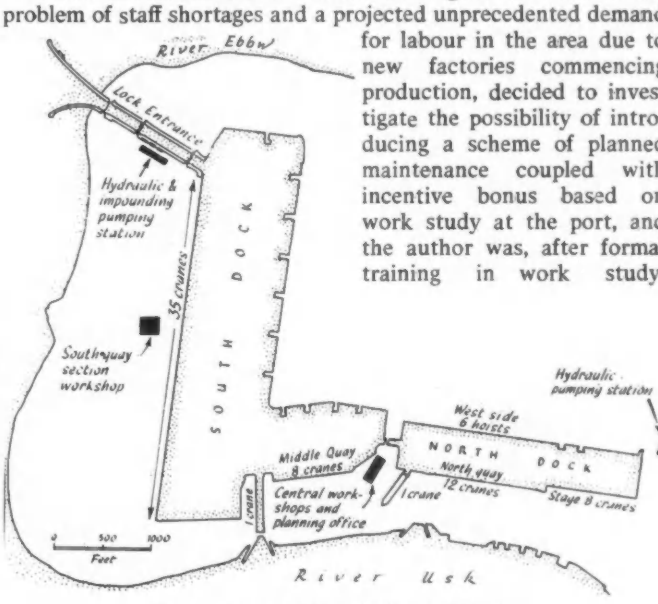


Fig. 1. General Plan of Newport Docks.

The initial task was to establish for each of the types of equipment at the port, schedules of the maintenance required and the frequency of carrying out the work. Discussions were held with other users of similar equipment, the Docks Engineer and the staff, to establish the necessary maintenance schedules and servicing periods.

It was very soon apparent, particularly in the case of dockside cranes which operate to no regular pattern, that no one criterion would give effective control of maintenance. If a specified tonnage handled were chosen, a particular crane could reach that tonnage in ten days, whilst another crane would not reach the

figure in ten weeks' operation.

The concept of dual control was then investigated, and it was found possible to establish a system whereby a crane could be inspected and serviced either after having handled a specified tonnage, or on the time elapsed since the previous servicing. The tonnage at which inspections and servicing are carried out varies according to type of crane and its control gear, and the figure men on one job would, in normal circumstances, mean that th work would have to be carried out in overtime periods; wherea the revised method enabled the work to be undertaken in norma working hours. In this particular application, the cost of th investigation exceeded the saving made, but the method sub sequently established has been repeated many times since, sc effecting considerable economies overall.

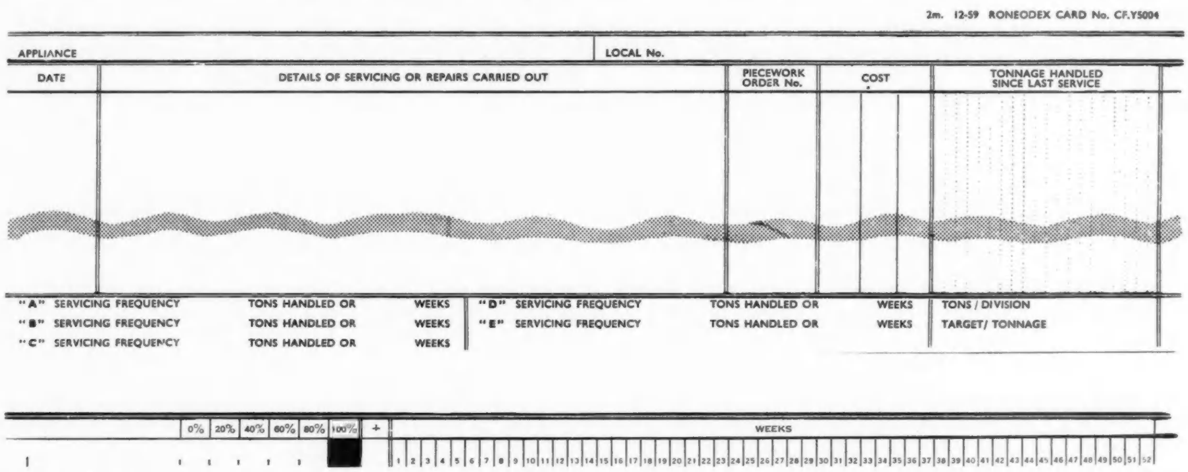


Fig. 2. Headings for edge type card used to control crane inspection by tonnage handled or time elapsed since last inspection. Beneath the thin-sheet record shown is a card for details of type of equipment, reference numbers and makers, and equipment details. Part of card shown only.

is revised in the light of experience to extend the periods between servicing as far as possible. A visible edge recording system was devised to control the inspection and servicing and, when supplied by a proprietary manufacturer of such equipment, proved entirely satisfactory in service (Fig. 2). The recording system also acts as a machinery register, each item of equipment at the port having a history card on which details of all servicing and repairs carried out are entered, so pin-pointing weaknesses of design by bringing to notice repetitive failures of components or assemblies or their need for continual adjustment.

The staff at the port were consulted during all stages of the discussions regarding maintenance requirements. Film shows, attended by the staff, were organised at which British Productivity Council films were screened. These film shows were followed by long and informative discussions between the staff who attended and their departmental officers.

At this juncture, it became necessary to carry out a major renewal of crane plug-box facilities at the South Quay, Newport, and it was decided to carry out the work under incentive conditions, preplanning the work as far as possible and using mechanical aids to the fullest extent. The "allowed times" for the various phases of the work were arrived at after discussions between the management and the staff concerned in the carrying out of the work. It was also agreed that the first stage would be work studied and a further meeting held when the Work Study Assistant's report on that section was available.

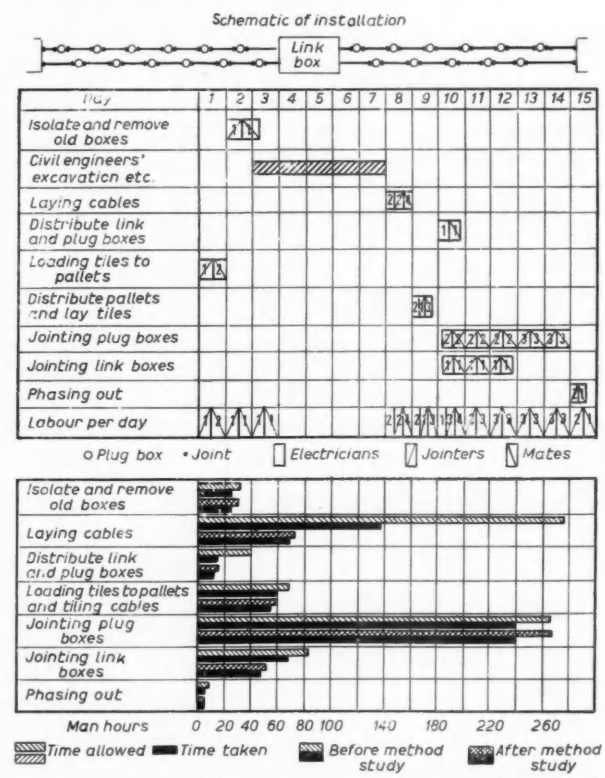


Fig. 3. Comparison of man hours and job sequence for renewal of plug box facilities, before and after method study.

Peak Planning Reduced

This report suggested various improved methods which were adopted when the second stage of the job was carried out and which resulted in a 20% reduction in man hours taken for the whole job (Fig. 3) and, in the case of one particular operation, reduced the peak manning required from 22 to six. The idea that six men could, without undue effort, carry out the same work as 22 men using the original method, created a very favourable impression towards work study on the part of the staff. The difficulty, with the number of staff available, in assembling 22

General Investigation

The general investigation into the work of the department was then commenced by the Work Study Assistant assisted by two other work study investigators, both of whom were drawn from the department and whose places during their training and the

investigation were temporarily covered by overtime working of the remaining staff.

It was very quickly apparent that, in common with many maintenance departments on day-work rates, staff were only 40% or 50% effectively employed, but that during breakdowns, the maintenance staff worked harder and sometimes longer than operatives on production work under incentive payment schemes. It was felt that the reorganisation of the department, so as to eliminate idle time together with method improvement where possible and the provision of new tools, etc., would produce the greatest savings immediaely with the minimum work study effort, any detailed method investigation being made subsequently and the jobs then being re-studied using the improved methods, tools and fixtures, etc.

The type of work being studied, necessitating in some cases a team of four or six men, rendered it difficult to employ the traditional methods of work study observation, so a modified random sampling technique was developed which enabled one observer to study simultaneously up to six men on any one job, the resultant study sheet being a multiple activity chart in correct chronological order, but to no definite time scale.

"Allowed times" were established for the various servicing routines previously established and for the repetitive maintenance items normally carried out. Applying this data, it appeared possible with the introduction of planned maintenance and work loading to effect a 25% reduction in the staff engaged on maintenance work at the port, despite the provision of an additional 25 electric cranes and associated fork-lift trucks. It was proposed that the staff so released from maintenance work could be organised into a new works section which could operate at any of the South Wales ports as required or, alternatively, undertake the day-to-day maintenance of marine craft previously carried out by contract labour The investigation also brought to light deficiencies in the provision of adequate tools and facilities for the staff, and in the routine inspection of appliances.

Revised Organisation

The present organisation at the port was devised, following approximately 18 months' investigation, and is shown diagrammatically in Fig. 4; the previous geographical deployment of staff having been modified by the transfer of all, other than the minimum number necessary for immediate first-aid repairs in any area, to the central workshop area from whence the staff are dispatched as necessary under the guidance of a planning office.

It is essential if efficient planning is to be practised that the planning staff are provided with up-to-date, adequate and accurate information as to the condition of appliances and equipment. To provide this information an inspection team of a chargeman fitter, chargeman electrician and chargeman rigger was established to inspect all equipment immediately prior to its becoming due for servicing, and to report back to the respective foreman on pre-printed stationery any defects found or work requiring to be done. In addition to their primary function of providing information, the inspection team, by carrying out on all occasions, a systematic inspection of all appliances in place of the former somewhat cursory inspections, have revealed minor flaws and fractures. These, if not detected, could have led to the major failure of components with consequent delay to shipping and perhaps serious accidents. Numerous incidents have been noted whereby immediate attention to developing defects found by the vigilance of the inspection team has avoided the expenditure of several thousands of pounds on major repairs which would have otherwise been necessary. The servicing routines being detailed, a less skilled person can now effect crane maintenance than was the case when maintenance and inspection were carried out simultaneously.

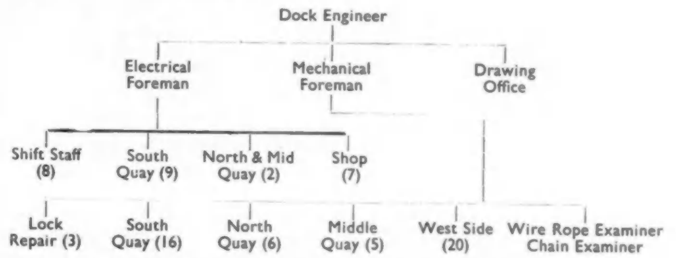


Fig. 4 (a). Maintenance staff during reference period. Details are given below. Total staff 78.

Electrical		*Mechanical*	
Shift:	4 chargemen electricians, 4 asst. electricians	Locks:	3 repairers
South Quay:	1 chargeman electrician, 4 electricians, 4 asst. electricians	South Quay:	1 chargeman repairer 11 repairers, 1 chargeman fitter, 3 fitters
North & Mid Quay:	1 electrician, 1 asst. electrician	North Quay:	1 chargeman repairer, 5 repairers
Shop:	3 electricians, 2 asst. electricians, 2 elec. lamp attendants	Middle Quay:	1 chargeman repairer, 4 repairers
		West Side:	1 chargeman repairer, 15 repairers, 1 chargeman fitter, 3 fitters
			Wire rope examiner, and chain examiner

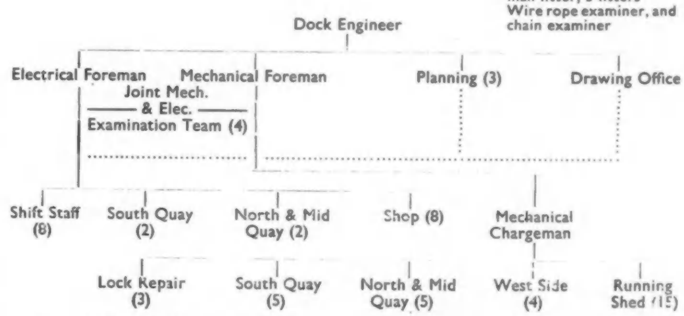


Fig. 4 (b). Staffing for planned maintenance at Newport Docks. Total staff 52. Details below.

Note that electrical shift staff cover repairs to mobile plant on the 10 to 6 turn, based on South Quay workshop. Electrical shift staff cover repairs to Middle Quay cranes on the 6 to 2 turn

Joint Staff: 1 chargeman fitter, 1 chargeman electrician, 1 repairer, wire rope examiner and chain examiner (may be same person)

Electrical		*Mechanical*	
Shift:	4 chargemen electricians, 4 asst. electricians	Locks:	3 repairers
South Quay:	1 electrician, 1 asst. electrician	South Quay:	1 fitter, 1 chargeman repairer, 3 repairers
North & Mid Quay:	1 electrician, 1 asst. electrician	North & Mid Quay:	1 fitter, 1 chargeman repairer, 3 repairers
Shop:	4 electricians, 2 asst. electricians, 2 elec. lamp attendants	West Side:	1 chargeman repairer, 3 repairers
		Running Shed:	2 fitters, 1 chargeman repairer, 12 repairers

The completed inspection forms pass from the inspection team to the respective foremen, who indicate on the form the measures to be taken, their recommendations regarding the individuals best able to carry out the work and the priority of the work. The forms are then passed to the planning office for work loading (Fig. 5).

The planning office staff, two of whom formed part of the original investigation team, make out job cards from the inspection forms, any minor repairs or adjustments being carried out simultaneously with servicing operations, so effecting economies in the utilisation of staff and minimising the time any appliance is out of commission. To assist the planning staff in assessing the "allowed time" for the various jobs, they have at their disposal synthetic times for various work elements together with the allowed times for the regularly carried out work which has been previously time studied.

The job cards employed (Fig. 6), one of which is issued for each job daily irrespective of the number of staff engaged on the job, indicate the description of the job to be carried out, the time allowed for the job, the labour required, the priority of the job, the date that priority was given and the cost allocation code, together with space for the staff engaged on the work to enter their names and the time they were engaged on the job.

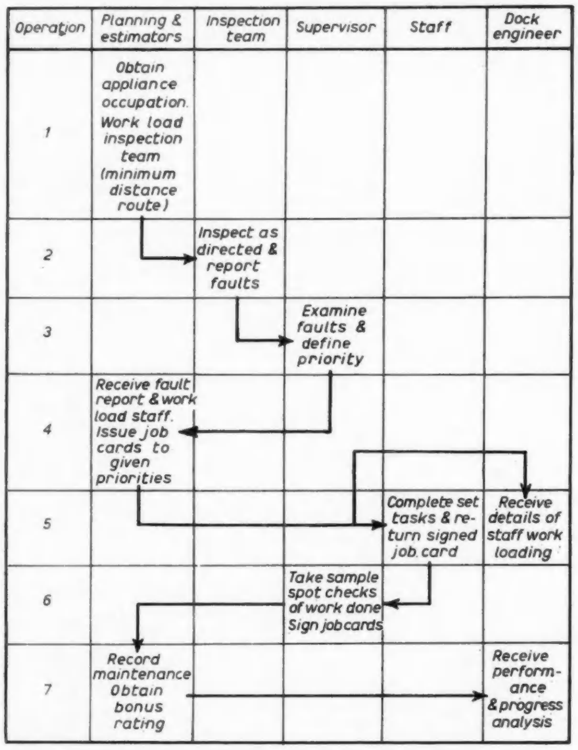
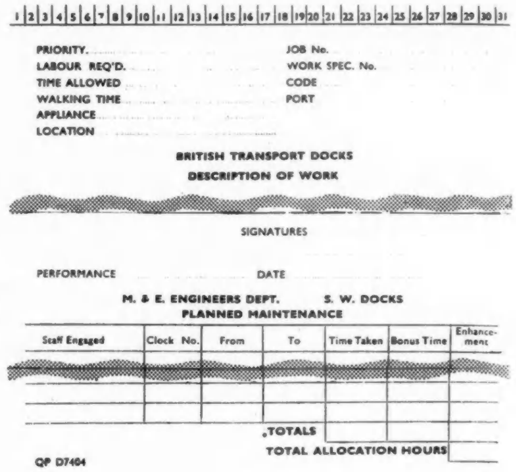


Fig. 5 (left). Planned maintenance organisation operated at Newport Docks.

Fig. 6 (right). Headings for job card issued for each job daily. Cards are stored in planning racks as shown in Fig. 7 (below).


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

PRIORITY.
LABOUR REQ'D.
TIME ALLOWED
WALKING TIME
APPLIANCE
LOCATION

JOB No.
WORK SPEC. No.
CODE
PORT

BRITISH TRANSPORT DOCKS
DESCRIPTION OF WORK

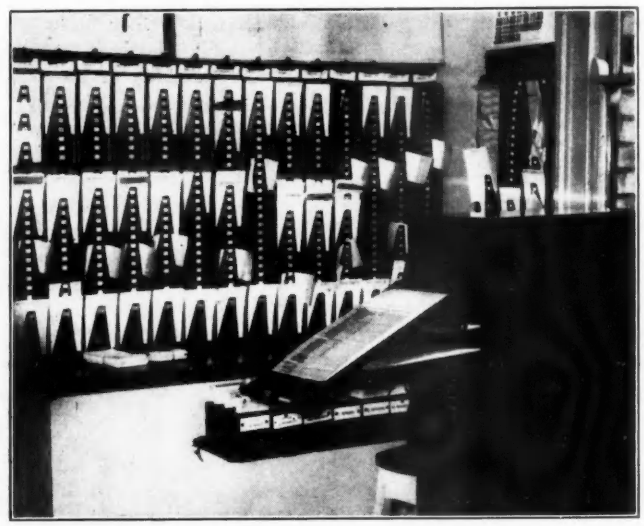
SIGNATURES

PERFORMANCE DATE

M. & E. ENGINEERS DEPT. S. W. DOCKS
PLANNED MAINTENANCE

Staff Engaged	Clock No.	From	To	Time Taken	Bonus Time	Enhancement
			TOTALS			
			TOTAL ALLOCATION HOURS			

QP D7404



The actual work loading is effected using the cards in conjunction with time-card racks which are mounted around the wall of the planning office, one rack being utilised for each member of the staff whilst the vertical apertures represent hours of the working day. This method of working has been in operation for two years and has proved entirely satisfactory in service.

The job cards, prior to being loaded to the planning racks (Fig. 7), are stored in pigeon-holed boxes; each division showing work available in any one of three priorities at any five major geographical locations for the normal maintenance gang strengths, i.e., one craftsman and mate, one craftsman and two mates, one craftsman and mate and two labourers, etc.

Planning

The planner/estimators, when work loading, consider the priority of the work, occupation of the plant, the availability of spares and materials, other work requiring to be done in the same area, instructions of the foreman regarding the particular staff to carry out the work, the weather and the compatibility of various members of the staff when working together. Close co-operation exists between the planning office and the operational departments, and servicing may be carried out in two parts timed to coincide with meal breaks of the operating staff if occupation cannot be given without impeding the work of the port.

All work is planned the preceding afternoon and staff reporting for duty each morning are handed a work programme slip by their foreman. This programme slip shows all the jobs each member of the staff is expected to carry out that day, also with whom he is working on each job, and normally allows 10 hr. to 10½ hr. work/man daily. The senior man on any job also receives the job card for that job. For convenience, the programme slips and job cards, when issued to the staff, are contained in plastic envelopes.

Staff, on completing the jobs, enter the starting and finishing times on each job card and, at the end of the day, hand them to the foreman. Apart from a "Combined Delay and Not on Bonus Form" no other documents are completed by the staff.

Minor breakdowns are met by the allocation of some staff at each area to low priority work with overriding instructions to attend immediately to any breakdowns in their area if they are of a minor nature, reporting the fact and duration to the planning office after effecting repairs. If the breakdown is of a more serious nature, the facts are reported to the planning office who deploy the staff as necessary, the whereabouts of all staff at any instant being readily available from the programme book at the planning office. The duration of any delays booked can readily be checked by reference to the delay records maintained by the operating department.

The completed job cards are, on the following day balanced against the time-clock cards to ensure that all hours worked are covered by job cards or "Delay and Not on Bonus Forms." The job performance for the team engaged on each job is then evaluated, using a ready reckoner, and the bonus for each man evaluated in bonus hours and minutes, all bonuses being individual.

Details of the work carried out are then entered on the record card of the particular item of equipment serviced and the job cards passed to the accounts section, who extract the details of each man's bonus earnings and enter them on a weekly summary sheet maintained for each member of the staff. From this, total wages and bonus are calculated. The accounts section finally allocate the total time spent on each job to the particular alloca-

tion code shown on the job card, which is then filed for a period before being destroyed.

Approximately 10% of the work carried out is chosen at random and checked, any defects found being rectified without any additional time being allowed for the rectification work.

The scheme outlined above has been operating for some two years, during which time the number of staff engaged on maintenance work in the department has been reduced by 25%, despite the taking over of the responsibility for the maintenance of marine craft and the increase in the number of cranes and associated mechanical handling appliances at the port.

Table 1. Typical Weekly Performance Return for Newport Docks Planned Maintenance Scheme.

	Mechanical Section	Electrical Section	Electrical New Work & Heavy Repair Section
Total time on bonus—hr ...	2,205	947	215
Bonus time paid—hr	489	256	63
Operator performance ...	90	95	100
Total hours worked by section	2,266	1,233	225
Section performance	85	85	95
Delay times for week—hr ...	*Nil*	5	1
Not on Bonus Time—hr ...	61	281	9
Travelling time—hr ...	18	—	9
Standby duty—hr	26	—	—*
Working meal breaks—hr...	—	3	—
% Delay time	*Nil*	0·35	0·6
% Not on Bonus Time ...	2·7	22·0	4·0

* This entry is for "No work owing to darkness."

A similar scheme has recently been introduced at another port in the South Wales Group, and it is anticipated that it will eventually be applied to all ports within the South Wales Group of Docks.

The amount of overtime working on maintenance has been reduced to almost negligible proportions, due to the efficient planning organisation being able to arrange for the necessary repairs and servicing to be effected during normal working hours whilst co-operation between the Mechanical and Electrical Engineer's Department and all using departments is now much closer than previously. The staff of the department have developed a pride in the job, feeling they can obtain a reasonable standard of living without the necessity for regular overtime or Sunday duty, which was always considered part of a maintenance man's normal routine. The staff appreciate, of course, that operational requirements may, on occasion, still make it necessary for overtime to be worked.

A typical weekly management summary of four weeks' working is shown in Table 1, all performances being on the 75/100 scale. All bonuses are individual and staff on the average receive approximately 25% to 30% above their normal weekly rate.

The success of planned preventative maintenance can be measured by the reduction in down time in a period following the introduction of such a scheme, as compared with a similar period prior to its introduction. In addition to this are the monetary savings which are made by management, and the enhanced morale and better team spirit of the staff arising in part from the increased wages and partly from being members of a more efficient organisation. At Newport Docks, the minutes delay/1,000 ton handled/crane were reduced from 0·0745 for 22 weeks of 1959 to 0·0383 for a similar period in 1961 for electrical delays. Mechanical delays were reduced from 0·060 to 0·0236 for the same period, despite a staff reduction of 25% on maintenance work and a 44% increase in the number of cranes; reflecting the measure of the increased efficiency of the department following the introduction of the planned maintenance with incentive bonus based on work study.

The author would like to express his thanks to the Chief Docks Manager, South Wales Docks, for his permission to compile this article and to the Mechanical and Electrical Engineer, South Wales Docks, for his assistance and co-operation.

Correspondence

To the Editor of "The Dock and Harbour Authority."

Sir,

I read with great interest your "Special Correspondent's" article entitled "An Appraisal of U.K. Port Working" in the September issue of "Dock and Harbour Authority."

Considering the immense scope of the subject, I think "Special Correspondent" has condensed his article quite cleverly but, of course, he really only poses the problems and the difficulties in solving them without putting forward many suggestions of his own.

"Special Correspondent" admits that he appears to concentrate on the problems of the Port of London and the writer would agree that this should be the focal point of any attempt to improve conditions in the ports of this country. With due regard, therefore, to the thought that one might be "rushing in where angels fear to tread," the suggestion is made that with a few bold strokes of imagination on the part of the authorities concerned, the Port of London could be made to deal with a much greater percentage of cargo more expeditiously and efficiently than it does now, even without undertaking any major schemes of rebuilding and development.

In the first place, there are a great number of public and private wharves along the river which are fully capable of dealing with quite large-sized vessels but in most instances, these wharves are only licensed by the Port of London Authority and H.M. Customs to deal with particular commodities such as bulk coal, automobiles, refrigerated foodstuffs, fruit and so on. If these could be "freed" to handle general cargoes of all types, then many more berths would become immediately available and thus save the congestion which every now and again occurs in the great Dock Systems and, furthermore, the Port of London Authority would have the spur of "outside" competition of which they have too little at the present time.

The next important thing is for Employers and Labour to get together and by some means or another bring in a shift-working scheme as far as port labour is concerned. It is a crying scandal that at the present time as many as 5,000 or 6,000 men are proving attendance daily and yet there are a great number of ships laying in the docks that would gladly employ labour for a night shift or possibly on a three-shifts per 24 hours basis. The surplus labour would thereby be taken up, the men concerned would earn overtime rates of pay instead of drawing just their "fall-back." There would be no opportunity for deputations to the Ministry of Transport led by Mr. Jack Dash and his colleagues. Of course some arrangements would have to be made for the same type of overtime working to be available at the wharves and warehouses, especially those where barges and road transport are dealt with as otherwise if shift-working applied to the ships only, we would soon have congestion of barges and road transport. The receiving wharves and warehouses must work similar hours to the docks in order to clear the conveyances. In busy times this difference in hours of work affects the port operation even now because most ships work till 7 p.m. daily and often on Sundays whereas at the wharves and warehouses "Never on a Sunday" is the theme song and rarely do they work after 5 p.m. on weekdays.

"Special Correspondent" puts his finger on one of the great difficulties about extending the use of containers in British Ports,

Correspondence—continued

i.e. the lack of fairly large areas in close proximity to the docks where containers can be dealt with for discharging and loading away from the ship or the ship's side. Here again it seems to the writer that there is a wonderful opportunity for the riverside wharves to come into the picture and make these available for the reception of general cargo and the loading and unloading of containers, the full containers being taken to and from the ship's side by barge thus benefiting the Lighterage Trade as well. Again, permission for the wharves to handle general cargo—from H.M. Customs' point of view—is essential to any such development.

The reference in the article to the larger vessels which are now to be built raises an interesting thought as some owners in the Short Sea and other Trades are deliberately envisaging the building of larger vessels than their trade actually calls for. This is not with a view to carrying larger cargoes in each vessel but to have more space and more hatches available for their existing cargoes so that by using containers, double sets of fast working gear, modern cranes and so on, they will obtain a much quicker turn-round on their existing services.

The writer believes that these things are going to come to pass and if the U.K. Ports do not set themselves out to cope, more and more trade will be diverted to the Continental ports where, in particular, Rotterdam and Hamburg are already making great strides and handling a great deal of cargo which used to be regarded as London's own.

London, S.W.1 — Yours faithfully,
10th November 1961 — "DRACO."

Dredging in Southampton Approaches

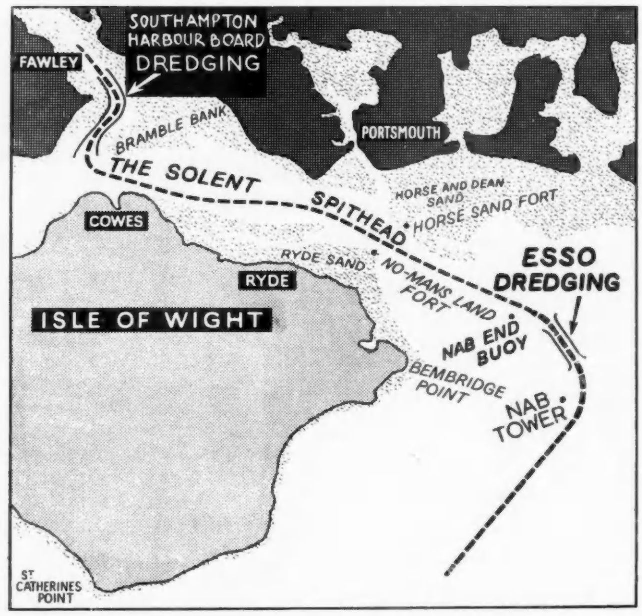
Every third ship to enter the port of Southampton is a tanker bound for the Esso refinery at Fawley. Last year more than 800 ocean-going tankers and 3,800 coastal tankers arrived at the Fawley marine terminal. The build-up of the Company's tanker fleet to meet increasing demands continues and one important contribution to increased efficiency and economy is the use of larger tankers. The first of five supertankers of 77,000 ton deadweight on order for the company was launched in June. Named Esso Pembrokeshire, she has the largest displacement of any ship built in Europe.

At present however, ships proceeding to Fawley are limited to a maximum draft of 41-ft. at neap tides and 43½-ft. at mean spring tides, and fully laden tankers of 77,000 to 86,000 tons deadweight have an arrival draft of 47-ft. (By comparison, the Queen Elizabeth has a loaded draft of 39½-ft.) The minimum depth of water required for the safe passage of these supertankers is, in fact, just over 55-ft., for allowance must be made for bottom clearance. An allowance of just over 10-ft. can be made however, for the high water neap tidal rise and, due to the peculiar tidal conditions in this area, high water remains for 1¾ hours. So, a dredged depth of 45-ft. enables a tanker to navigate the approaches at high water and to proceed to Fawley, where high water is also later than in the approaches, and still berth at high water.

The most important limiting factor is in the outer approach to Fawley near the Nab Tower, off the eastern end of the Isle of Wight. Recent surveys carried out indicate that there is about 39-ft. of water over the Nab Shoal—6-ft. short of the depth required. There is also a similar limitation alongside the refinery's jetties and in the approach to them from the main navigational channels.

The removal, by dredging, of the limitations in the inner approach channel (between Brambles and Calshot) and the approaches to and alongside No. 5 berth at the marine terminal presents no problem. They are in sheltered waters; the nature of the spoil to be removed is such that conventional bucket dredging can be used; and past experience has shown that little or no maintenance will be necessary to keep the required depth.

To remove the restriction at the Nab, however, is a much more complex operation. The Nab shoal forms the approach to Spithead at the eastern end of the Isle of Wight and is used by all large deep-drafted ships entering and leaving Southampton. It is about three-and-a-third nautical miles wide and just over one nautical mile long. The area is virtually open sea and subject at times to severe weather conditions; the nature of the spoil to be removed—large flints and small gravel down to 2-ft. and underneath, down to 10-ft. below sea seabed, fine gravel and sand—will require a special kind of dredging; and the extent to which any channel would silt up and therefore require maintenance cannot be known definitely until at least a part of it is dredged to the required depth.



Towards the end of last year, the Esso Petroleum Co. placed a contract for the test dredging of a small area of the Nab shoal, 1,200-ft. by 300-ft. Seabed investigation by boreholes was carried out, and hydrographic surveys were made by Comdr. D. H. Macmillan of the Southampton Harbour Board on behalf of the company. As a result of these findings and after meetings between the company, the Southampton Harbour Board and the Trinity House pilots' representatives, a channel 500-yds. wide and 2,100-yds. long was tentatively agreed, with light buoys marking its path.

Now, subject to the permission of the Governmental and Port Authorities concerned, the company has undertaken, in conjunction with the Southampton Harbour Board, the task of removing all restrictions to deep-drafted ships. The task will involve removing more than 7 mn. cu. yds. of spoil, at an overall cost of well over £1 mn.

Diesel Electric Locomotives for Hong Kong

The last three steam engines in service on the British Section of the Kowloon-Canton Railway, which runs between Tsim Sha Tsui and the Chinese frontier at Lo Wu, were recently replaced by three 1,800 h.p. diesel electric locomotives powered by a 16-cylinder, two stroke engine with six traction motors mounted on two six-wheel bogies. They are much more powerful than the railway's existing five diesel electric locomotives and can pull a train of 15 or 16 loaded passenger coaches at a maximum speed of 62 miles an hour.